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CONTENTS

Review			1
A New Look for Italy's Sulphur Industry			2
Sulphur and Pyrites Freight Rates			7
Prices and Trends			10
United States Sulphur			16
Sulphur in Mexico			21
United Kingdom Sulphur			26
Pyrites Flash Roasters Adapted for Brimstone Burning			33
Current Events			
Cyprus	1959—First 10 Months Exports		34
Canada	Integrated Sulphuric Acid and Leaching Circuit		34
U.S.A.	Closure of Bay Ste. Elaine Dome		35
	Sulphuric Acid for Caprolactam		35
West Germany	Largest Carbon Disulphide Plant		35
Switzerland	Carbon Disulphide Plant for U.S.S.R.		36
Yugoslavia	World's Largest Superphosphate Plant		37
Japan	Sulphuric Acid—Jan.-June, 1959		37
Philippines	Maria Christina Fertilizer Plant		38
Poland	Trade Agreement		39
Statistical Appendix			40
Index to Advertisers			xvii

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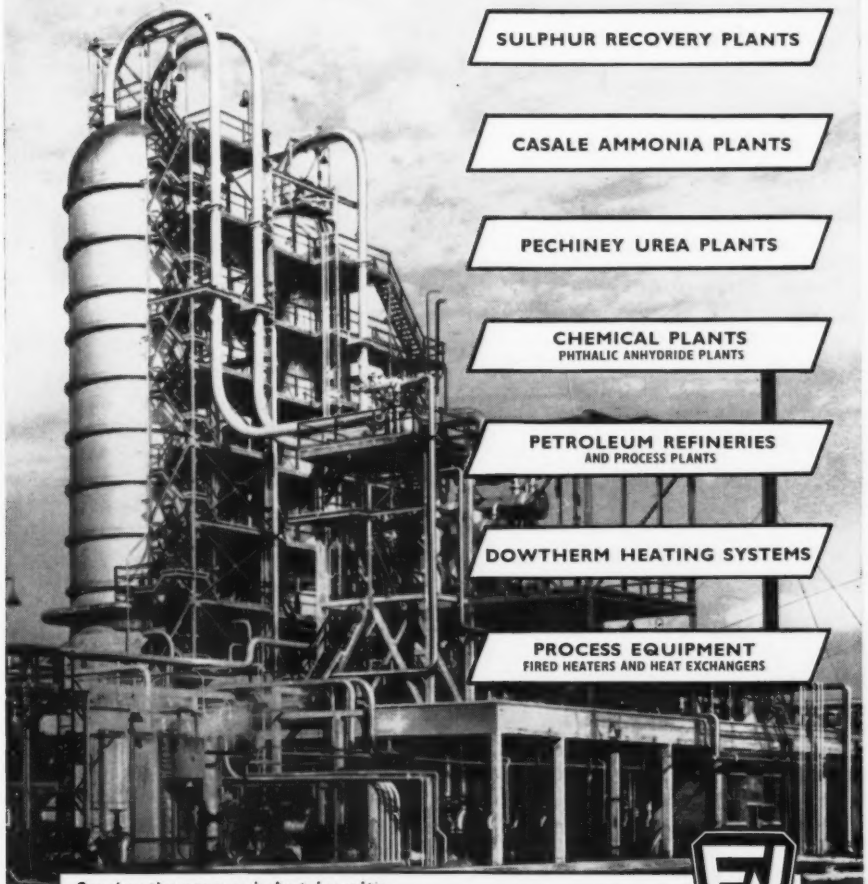

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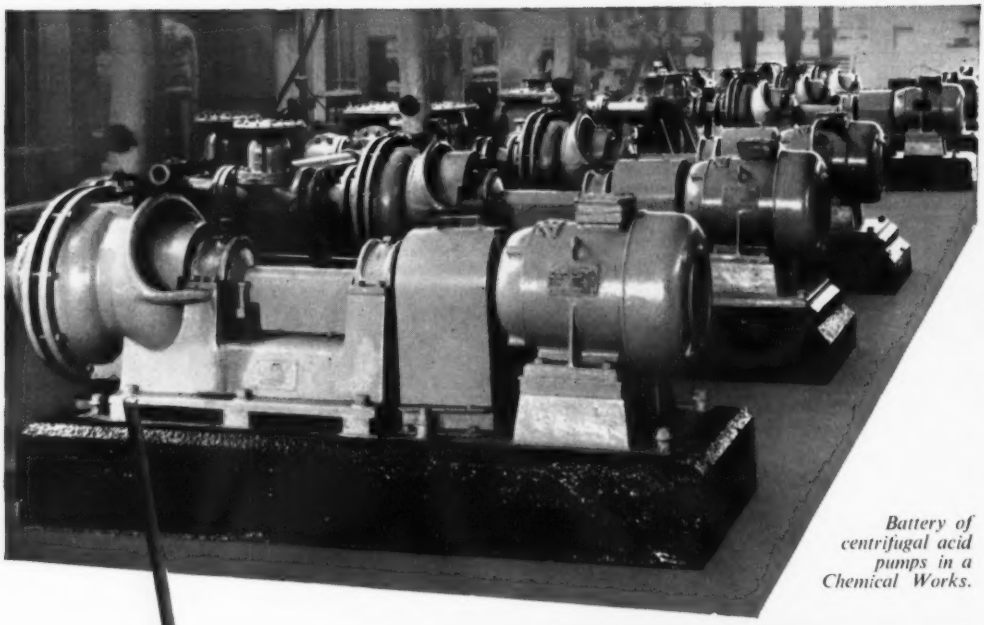

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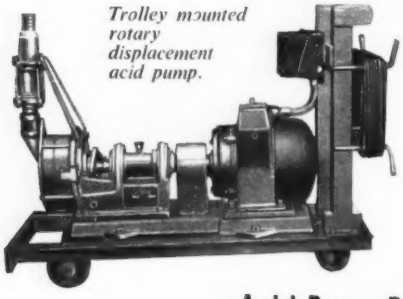

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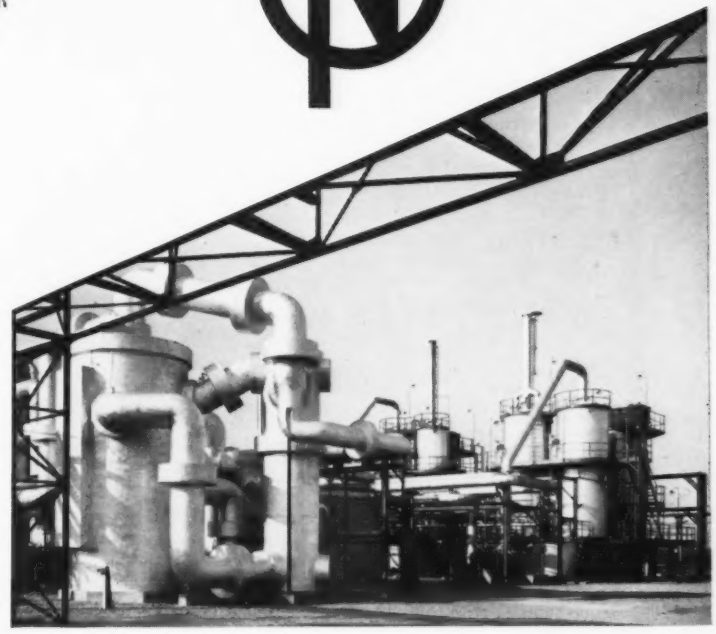

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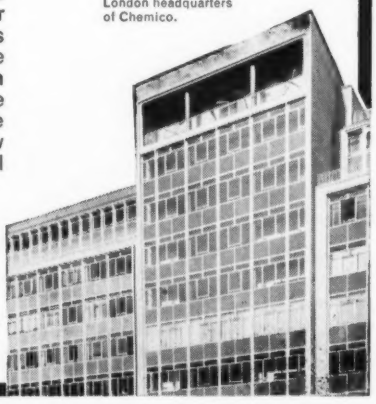

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Review

World prices of sulphur are very unstable due to the mounting pressure of new supplies on the market which has failed to respond to the increased level of consumption in 1959. On the contrary in the principal centres of competition, notably W. Europe, effective brimstone prices of $24.50-$28.50 per ton c. & f. are $2 lower than one year ago. European pyrites remain based on 60s. per tonne f.o.b. Huelva, the level established last autumn.

World supplies of sulphur in 1959 increased by about 6% to 16.5 million tons but only fractionally exceeded demand. Higher recovery of brimstone, notably from natural gas in France and Canada, was compensated by restricted Frasch sulphur production in U.S.A. and Mexico. World brimstone stocks are estimated to have declined by 200,000 tons to 5½ million tons. World production of pyrites rose under the stimulus of domestic consumption in the major pyrites producing countries, notably Japan, Spain and Portugal, but trade in European pyrites declined 3%. The Grand Isle dome coming on stream in the U.S.A. and additional recovery capacity operating in France and Canada is expected to widen the gap between supply and demand substantially in 1960.

The Sulphur Industry of Italy, facing probably the fiercest crisis of its chequered history, is meeting it by complete reorganisation founded on mining and ore treatment and designed to lower production costs. All but abandoning the manufacture of fused sulphur, the country's vast native ore resources are to be used as such and as concentrates, mainly in sulphuric acid manufacture.

The impact of **freight rates for sulphur and pyrites,** which is reviewed by Mr. C. F. H. Cufley, is a key feature in Europe's highly competitive sulphur market. At present brimstone from the Gulf and pyrites from Huelva can be transported at virtually the same cost per unit of sulphur, but the slump in freight rates has blurred the picture, and under "normal" conditions sulphur in pyrites is expected to be favoured again.

In the **United States** despite the adverse influence of the steel and copper strikes sulphur demand during the first nine months was exceptionally strong and total use in 1959 is estimated to be 6 million tons, the highest on record. Owing to restrictions on Frasch sulphur output which in 1959 totalled 4.55 million tons, stockpiles were depleted by 650,000 tons, notwithstanding imports from Mexico and Canada of about 650,000 tons and recovered sulphur output of 651,000 tons.

Sulphur production in Mexico in 1959 totalled 1.38 million tons of which over 93% was Frasch sulphur. Exports declined about 4% to 1.03 million tons as the result of lower shipments to countries outside North and South America; U.S.A. remains Mexico's largest market taking up 65% of deliveries.

Sulphur consumption in the United Kingdom in all forms in 1959 rose to 1,152,000 tons of which indigenous resources accounted for 51½%. Production of sulphuric acid of 2.43 million tons (100% H_2SO_4), in the raw materials supply pattern of which brimstone and anhydrite predominated, rose to a new peak and non-acid sulphur uses increased under the stimulus of strong industrial activity.

A simple means to adapt **pyrites flash roasters to burn brimstone** has been developed by Fertilisers and Chemicals Limited of Haifa.

A New Look for Italy's Sulphur Industry

EXCEPT FOR BRIEF PERIODS coinciding with world-wide sulphur boom conditions, the sulphur industry of Italy, encompassing mines on the Mainland and in Sicily, has been in a state of crisis necessitating Government intervention and financial aid. The root cause of the recurring difficulties are primarily political and social problems, especially in Sicily, yet it has been this factor which has induced successive governments to step in and give the industry a new lease of life.

The dominant feature of recent years' Government aid has been the enforcement of dual pricing of domestic and export sales respectively, and minimum price guarantees to producers. During the early 1950's when sulphur prices on world markets were reasonably stable, the very high domestic sales price went a long way towards enabling Ente Zolfi Italiani — the para-governmental enterprise responsible for the organisation of sulphur supplies, sales and the management of Government financial aid to the mining industry—to secure an average income commensurate with costs, despite charging substantially less in export markets. Aid in support of minimum price guarantees has been in several guises, all designed to promote investment and modernisation of the mines. Thus the Government has sponsored loans to producers and special subsidies in respect of production, exports or even adverse operating conditions.

The rapid fall of world market prices after 1956 dealt a severe blow to this carefully balanced system of financial support. Despite palliative measures by the EZI—notably concentrating the export sales effort only on selected markets to preserve available subsidy funds, gradually withdrawing subsidy from uneconomical producers and inducing the more economical producers to accelerate modernising by generous investment grants—it became evident that the domestic consumers could no longer carry the disproportionate share of the overall cost of sulphur production, nor would the Government continue to augment its aid progressively as the gap between costs and world prices widened. Survival of the industry had become contingent on a new basis of operations being found.

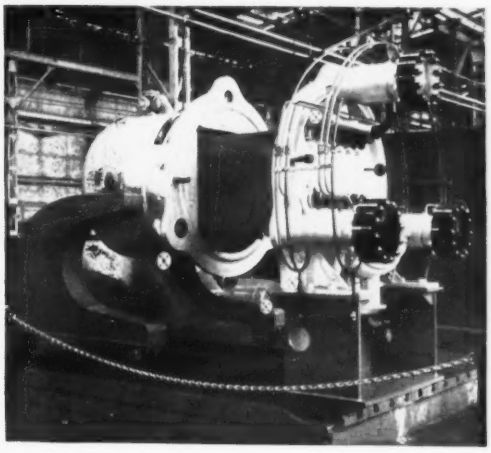
Hitherto, the main emphasis rested on endeavours to reduce the cost of fused sulphur production, and a large number of different processes had been developed and several installed with varying degrees of success. As the result of detailed studies by EZI in which the Battelle Memorial Institute and Frazer Weir & Associates of Chicago assisted, it was decided to centre the main rehabilitation effort on mining and ore beneficiation.

New Objectives

From the many alternatives, three cardinal objectives were finally determined and proved in practice :—

1. *Mining.* To increase by 50% the productivity of sulphur ore mining which would result in the cost of mined ore being lowered by about 40% to Lire 3,000-3,200 per tonne (£1 15s.-£1 17s.= $4.90-$5.20 per ton) of ore of 23%S, equal to Lire 13,500-14,000 per tonne (£7 17s.-£8 2s.=$22.00-$22.75 per ton) of sulphur contained.
2. *Beneficiation.* To subject crude ore to beneficiation by flotation, instead of fusion, and to produce a sulphur concentrate containing 90%-94%S. Whereas the production of one tonne of fused sulphur of 98%-99½%S requires 7 tonnes of ore, one tonne of concentrate entails the use of only 4.5 tonnes of ore. This, coupled with the significantly lower operating costs of flotation, allows one tonne of sulphur contained in concentrate to be produced for Lire 19,000-20,000 (£11 0s.-£11 12s.=$30.90-$32.50 per ton).

3. *Sulphuric Acid Manufacture.* To use crude ore or sulphur concentrates direct in the manufacture of sulphuric acid. This offers substantial economic advantages which are enhanced the nearer the consuming plant can be located to the source of ore or concentrate supplies.



Pressure filters for the concentration of fused flotation sulphur.

These objectives have now been incorporated in a five-year programme, in the course of which the industry is being rationalised and to a large extent vertically integrated. The outstanding feature of the programme is the envisaged reduction of crude ore output to 1.5 million tonnes—about 25% less than in 1959. The closure of the large number of marginal mines will be compensated by the greater productivity at those remaining active. It is estimated that ultimately the mining labour force will be reduced by 2,000-3,000 men. Approximately one-third of the crude ore output will continue to be fused and the output will meet solely the needs of domestic agriculture. In the interim period the use of fused sulphur will be progressively replaced in all industries where this proves practicable, such as the manufacture of CS_2 in retorts.

The bulk of the ore production, in the form of crude ore and concentrates, is to be devoted to the manufacture of sulphuric acid which is to serve, notably in Sicily, as the basis of a rapidly growing chemical industry in which fertiliser manufacture is to play a major part.

In view of the magnitude of the programme and the relatively short time in which it is to be carried out, the Italian Government and the Authorities in Sicily are passing special legislation to deal with the resultant financial and social problems. The mining companies are being granted interest-free loans to purchase plant; redundant labour is receiving public assistance in becoming re-established in alternative employment; the new chemical industries are being assisted with capital at low interest rates; special rates of carriage for ores and concentrates to consuming works are being established; and research and development work to ensure the rapid realisation of the programme is being maintained.

Current Operations

Production. The results of the past eighteen months already reflect the earnest of the industry. Production of fused sulphur, which in the autumn of 1958 averaged 16,000 tonnes monthly, is now reduced to 10,000 tonnes.

Fused Sulphur Production

	tonnes		
	1/7/58—30/6/59	*1/7/59—30/12/59* (prelim)	Rate of Change
Sicily ..	102,150	39,800	—22%
Mainland ..	33,826	18,300	+ 9%
TOTAL ..	135,976	58,100	—14%

It is significant that whereas prior to 1958/59 more than three-quarters of the fused sulphur output originated in Sicily, the mainland output, entirely from mines and plant of Soc. Montecatini or its associates, has increased its share in the second half of 1959,

to nearly one-third, mainly as the result of the operations of the new distillation plant at Passarello.

The completion of the plant at Trabia significantly boosted the production of sulphur concentrates, which for the first time in the 1958/59 trading year, assumed some importance. Confined wholly to Sicily, output of concentrates containing an average of 75%S and 15% moisture totalled 19,948 tonnes. As output of fused sulphur declined during the year, this sector of the industry became more active and this trend is reflected in the results of the second half of 1959 when 16,000 tonnes were produced, and the monthly rate of output rose to over 4,000 tonnes by December.

Production of sulphur ore and sulphur wastes in 1958/59 totalled 289,607 tonnes with an average content of 24%S and was wholly devoted to sulphuric acid manufacture. About 82% of the output came from Sicilian mines and the balance from the mainland. Not included in this total is some 6,100 tonnes of filter cake also used for acid making. In the second-half of 1959 the rate of crude ore output rose about 15% to an annual rate of 330,000 tonnes to meet the growing needs of the new sulphur ore-based acid plants at Pomezia where Squibb/Rumianca produce tripolyphosphate and at Priolo where Sicedison make complex fertilizers.

Export Sales

In the course of the trading year ending 30th June, 1959, EZI's ability to compete in world markets progressively declined and despite the inclusion of sulphur in a number of bilateral trade agreements and an intensive sales drive, new sales contracts for only 60,097 tonnes augmented by a small carry-over tonnage of 10,010 tonnes were concluded. Actual deliveries were only 36,821 tonnes. During the subsequent five months the position further deteriorated and sales to the end of November, 1959, totalled only 6,281 tonnes.

An analysis of these sales shows that of the 36,821 tonnes actually shipped against contracts during the trading year, 55% were delivered from stockpile and 45% from current production. The nett revenue per tonne compared with 1957/58 declined by Lire 3,300 (£1 18s. 6d. per ton) to Lire 17,259 (£10 per ton) after disbursement of Lire 4,893 for rail and sea transport, bagging, insurance, commissions, bank charges, etc.

Exports

Tonnes

	January—June, 1959	*July—November, 1959*
Austria	798	956
France	8,595	1,585
Yugoslavia ..	2,527	50
Tunisia	1,140	2,500
Morocco	2,000	1,000
Fiji	—	40
Jordan	—	150
Czechoslovakia ..	3,000	—
Portugal	770	—
Egypt	7,962	—
TOTAL ..	26,792	6,281

Domestic Sales

Total crude sulphur deliveries to the home market in 1958/59 were 11% less than in the preceding year and amounted to 92,357 tonnes, including a small quantity of recovered sulphur. The gross revenue from these sales was Lire 48,302 per tonne, nearly 2½ times the ruling return from export sales. Transport charges and a subsidy to compensate manufacturers of carbon disulphide, refined sulphur and sodium sulphite destined for export, resulted in a nett revenue of Lire 44,304 (£25 15s.=$72 per ton). The overall gross return from export and domestic sales, and allowing for deliveries to stockpile, declined to Lire 39,703 (£23 1s.=$64.50 per ton), only 1½% less than in the preceding year mainly due to the diminishing volume of exports.

Sales of sulphur concentrates rose to 19,948 tonnes containing 77% sulphur (dry weight) and realised Lire 22,186 per tonne (£12 17s.=$36 per ton) nett. The bulk was consumed in carbon disulphide manufacture and only 2,184 tonnes concentrates was sold

to acid makers, mainly for testing and development work. The use of sulphur concentrates in carbon disulphide manufacture is of particular interest; S.N.I.A. Viscosa, whose engineers succeeded in adapting their retort process to this material, is reported to find this material qualitatively acceptable and appreciably more favourable as regards cost than fused sulphur.

During the year 1958/59 consumption of crude sulphur in grinding plants and sulphur refineries declined by some 6,000 tonnes partly due to the virtual cessation of exports of refined sulphurs and also due to the substitution of recovered sulphur and of a greater quantity of ground sulphur ore. Increased sodium sulphite manufacture accounted for over 2,000 tonnes more crude sulphur being used and, authorised and subsidised by EZI, the industry supplied export markets. Demand for carbon disulphide manufacture showed the largest advance of about 8,200 tonnes sulphur, largely due to the favourable trend in the viscose industry and the advantageous price of sulphur concentrates which accounted for the increased consumption.

Some of these trends were reversed during the second half of 1959. The overall demand was only fractionally higher than during the first half year, but deliveries to domestic grinders and refiners advanced by over one-third while CS_2 manufacture receded by one-sixth.

Domestic Sales

	1st Half 1959			2nd Half 1959 (Prelim)		
	Fused	*Concentrates**	*Total**	*Fused*	*Concentrates**	*Total**
Grinding and Refining ..	17,614	—	17,614	23,800	—	23,800
Carbon Disulphide	14,696	9,370	24,066	7,600	12,000	19,600
Sulphur Dioxide :						
Pulp	5,485	—	5,485	8,500	—	8,500
Other	*n.d.*	—	*n.d.*			
Polysulphides	1,466	100*e*	1,566	1,500	100	1,600
Sodium Sulphite	*n.d.*	100*e*	*n.d.*	600	100	700
Sulphuric Acid	—	1,680	1,680	*g*	*g*	*g*
Miscellaneous	3,821	—	3,821	1,000	—	1,000
TOTAL ..	43,082	11,250	54,332	43,000	12,200	55,200

* S. Content. *n.d.* No Data. *e* Estimated. *g* Less than 100 tons.

Stocks

At the end of June, 1959, stocks of crude sulphur in EZI warehouses totalled 226,008 tonnes, representing an increase of 8,500 tonnes during the trading year. During the subsequent five months stocks of crude sulphur further rose by over 5,000 tonnes to total 231,099 tonnes at the end of November.

Development Works

In the rehabilitation plans of the industry, the German/Italian Committee of Economic Collaboration plays an important part. With funds of D.M. ½ million (£40,000) voted by the German Government, Italian and German experts and research scientists started work on the 1st September on various aspects of production, with particular reference to determining costs of different sulphurous raw materials at varying levels of production, labour productivity and problems of re-employing redundant sulphur miners and the potential cost structure and capital needs of the Italian chemical industry.

Specific high-priority development tasks are improvements to the underground ways of the major mines Trabonella, Cozzo Disi, Trabia and Passarello. Of greater importance and already in operation are the flotation plants at Cozzo Disi and Trabia in Sicily which have a combined daily throughput capacity of 1,200 tonnes ore. Installed capacity

at three plants is at present 75,000 tonnes annually of concentrates containing 90% sulphur and 15% moisture.

Government aid in this particular sector includes a Bill passed with effect from the 30th June, 1959, by the Ministry of Industry and by the Treasury providing for a payment to Minera Trabonella of Lire 380 million (£217,000) for the installation of a flotation plant.

Experimental work on sulphur concentrates is being pursued in several directions. At the Terrapaleta Research Centre EZI is testing a Motosi pilot flotation plant which is

General view of the mine at Trabonella.

expected to offer greater economy of operation. The Svoronos ore treatment process is being tested and at the Krupp Laboratories at Essen a novel pilot plant is being developed. Other experimental work at Terrapaleta concerns the behaviour of sulphur concentrates and fused sulphur on vibratory screens and the Battelle Memorial Institute at Frankfurt a/M pursues similar research with ultra-high wave frequencies. Problems of sulphuric acid manufacture, encompassing raw materials as well as roasting and conversion to SO_3 are being examined by EZI in conjunction with De Nora of Milan, Chemiebau Dr. Zieren of Cologne, Chemical Construction (G.B.) Limited of London, and Battelle Memorial Institute of Frankfurt.

At present the roasting capacity of crude sulphur ore (23%S) at two Sicilian sulphuric acid plants is 400,000 tonnes annually. In contrast fused sulphur output is being cut back, by closing uneconomic mines, so much so that the addition within the last eighteen months of two sulphur installation plants—Cia. Generali Zolfi at Saponaro and Soc. Montecatini at Passarello—and their successful operation, was not apparent from statistical results. Finally much interest is focussed on the work of the development section which, in co-operation with Sturtevant (U.S.A.), aims to use sulphur concentrate to produce micronised and wettable sulphurs and sulphur mixtures with pesticides.

Conclusion

The cardinal feature of the latest, and it is hoped by those concerned, the last major reorganisation of Italy's sulphur industry, is its acceptance that it can no longer play a part on world markets as an exporter of fused sulphur, and that its sulphur ore resources are best employed to meet domestic needs. This point was made in a review of the industry five years ago in "SULPHUR" when in the light of prevailing world sulphur trends it was indicated that the very measures now being adopted offered the only practicable course; the political and especially economic and social circumstances have, however, only recently become conducive to implimenting these changes.

As Europe's third largest consumer of sulphur in all forms and the ninth largest in the world, Italy depends predominately on her indigenous pyrite resources to feed her growing acid industry. The new emphasis in the use of her abundant sulphur ore indicates a rapid change in the consumption pattern. Sgr Lanza di Scalea, the President of EZI, postu-

lated last summer that the aim of the industry must be the reduction of sulphur ore costs to Lire 2,500 per tonne. It is likely that even at the somewhat higher level now prevailing the unit cost of sulphur at new specially sited sulphuric acid plants compares favourably with that of pyrites at established pyrites based acid plants. To the industry as a whole, the dual availability of cheap sulphur represents a source of strength in the increasingly competitive conditions of the sulphuric acid and especially of fertilizer industries in the Common Market. The absolute protection which Italy's crude sulphur industry enjoyed against imports still prevails, but there is now little doubt that before long the industry will be able to dispense with the protective barrier and open the Italian market to crude sulphur from abroad even before the requirements of the Rome Treaty for the liberalization of trade imposes this. The most likely customer of imported sulphur will be the long suffering viscose industry of Northern Italy and S.N.I.A.'s new methane/liquid sulphur plant at Pavia merits the benefits of cheap sulphur supply. The proximity of Lacq makes French recovered sulphur the likeliest source for North Italy, although with the realisation of E.N.I.'s plans at Gela in Sicily, where, once the proposed hydrogenation plant is operating at the oil refinery and sulphur recovery facilities are also installed at coke-ovens, some 80,000 tonnes of indigenous low cost recovered sulphur will be at the disposal of Italian industry. The discovery in Sicily of potash deposits, coupled with the island's favoured situation in relation to phosphate deposits of North Africa and the Near East, hold out great prospects for this as a new centre of fertilizer manufacture, in particular of complex and compound fertilizers. In place of sulphur as such in the assessment of costs, the availability of cheap sulphuric acid will make its impact and strengthen a trend which is evident throughout the world.

SULPHUR AND PYRITES FREIGHT RATES

by C. F. H. CUFLEY, F.I.C.S.

THE FACTOR since World War II most affecting the shipment of raw materials for the sulphuric acid and superphosphate industries, has been the emergence of abundant sulphur at competitive prices, firstly from American producers in the Gulf of Mexico, latterly from Mexico itself and most recently, Lacq sulphur obtained during the purification of natural gas in France. It is a little early to assess what will be the impact of the last-named as far as the bigger consumers are concerned as the limitations of the port of shipment, Bayonne, must to some extent hamper sales efforts—in view of the higher freight element involved in chartering relatively small ships. But, as far as the smaller works in the United Kingdom, Eire and Belgium are concerned, Lacq sulphur has already made big inroads into what was formerly exclusively a pyrites market and more recently the preserve of the United States and to a lesser extent Mexican Frasch sulphur.

In the immediate post-war years a shortage of non-ferrous ores coupled with a ready and lucrative outlet for acid, led Continental roasters of blendes to buy American sulphur and so put their otherwise idle plant to profitable use. A number of pyrites roasters followed this example, mainly because of the difficulty at that time of disposing of residues. Thus, the pre-war pattern where an important section of the sulphur needs of U.S. Atlantic Coast acid plants was met by imported pyrites was completely reversed. During the 1930's pyrites from Huelva to Northern Range ports still provided one of the most important traffics for west-bound shipping and when the Spanish War interfered

with their source of supplies, pyrites producers in Portugal shipped across the Atlantic several hundred thousands of tons of ore ex-dump, some of which, for a decade, had lain submerged beneath a luxuriant vegetation.

When the question of shipping full cargoes of Gulf sulphur to Europe was first broached shipowners shewed great reluctance to consider it. There was much talk of "free acid" damaging ships' plates and brokers introducing the business had to use all their powers of persuasion to make the first "fixtures" at around $14 a ton freight. For several years this prejudice persisted and it became accepted that sulphur had to be penalized to the extent of an extra one or even two dollars a ton freight over the going rate for phosphate from nearby Florida. But, in time, helped on by the difficulty of shipowners in finding cargoes in the collapse which followed the Korean War, sulphur attained respectability and acceptance as a normal harmless tramp cargo. Today shipowners entertain it as readily as they do grain, sugar or any other commodity from the Caribbean region.

It is not easy to determine how much the freight element has influenced sources of supply during the past ten years, in view of the existence over much of that period of commodity shortages creating a sellers' market and the distortions of the freight structure brought about by the Korean and Suez affairs, with their aftermath, a huge world surplus of shipping. To draw any valid conclusions from the movements of pyrites and sulphur freights there are two prerequisites, that the voyages compared employ tonnage of similar size and that continuous charterings are made in both of them. Because freight bookings for sulphur to the Continent are sporadic, months often passing without the report of a chartering, this trade is not reliable as an indicator. Nor is the pyrites traffic to Britain, although a regular one, because the average size of ship employed, 2,000 to 3,500 tons, is less than half the norm for Continental destinations. But sulphur from U.S. Gulf to the U.K. and pyrites from Huelva to Holland/Belgium fill the bill, both providing plentiful charterings and using ships of 8,000 to 9,500 tons as a rule. When fighting ceased in Korea the Gulf/U.K. sulphur rate stood at 140s. a ton, but by mid-1952 it slumped to 70s. Sliding further, it hovered around the 50s. mark from end 1952 until the autumn of 1954. Then came the European fuel crisis which lifted it during the next two years to over 100s., culminating in the payment of 137s. 6d. a ton during the Suez incident. In the general destocking which ensued and the collapse of the

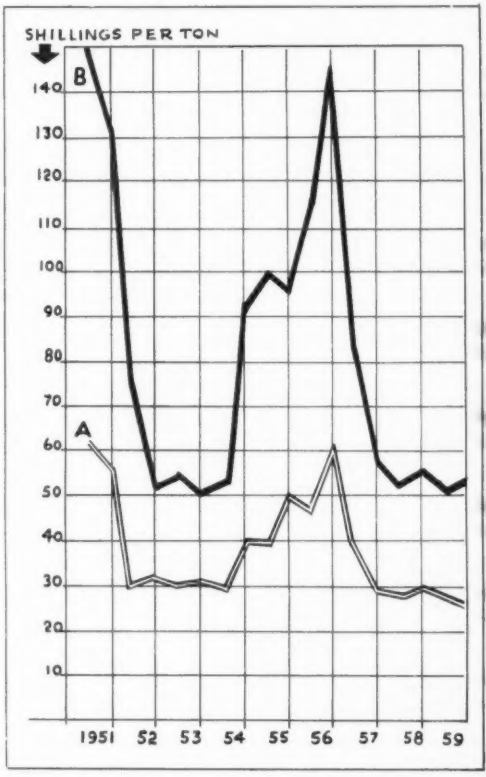


Fig. 1. A, Freight rates for full cargoes of pyrites shipped from Huelva to Holland or Belgium; B, Freight rates for full cargoes of sulphur shipped from U.S. Gulf to United Kingdom.

American coal trade to Europe during 1957 sulphur from the Gulf to this country paid no more than 45s. a ton, at which it stood until the late autumn of 1959. The boomlet in freights brought about by this winter's shortage

of stockfeed grains hoisted it up again to 52s. 6d., where it remains stable. By comparison, movements in the Huelva/Continent pyrites rate have been far more modest. Admittedly, it touched 62s. 6d. once during the Korean War and 56s. a ton at the time of Suez, but for the greater part of the last decade it has stood somewhere between 22s. 6d. and 27s. 6d. a ton.

The conclusion to be drawn from a comparison of the two voyages is that in times of sudden tonnage shortage importers from the U.S.A. are likely to suffer much greater freight increases on their sulphur cargoes and for far longer than those affeting users of Mediterranean pyrites. This, in part is due to the near Mediterranean market having become somewhat of a backwater, reacting only partially to trends in the major routes. Much of the shipping serving the area is, through age or other reason, not best suited to meeting the ravages of the North Atlantic, especially in winter. Also quite a number of regular traders to the Iberian Peninsular cannot detach themselves from it when higher profits offer elsewhere, because of obligations imposed by their Governments to take certain outward cargoes, e.g., coals and sulphate of ammonia to destinations adjacent to the homeward loading ports for pyrites, phosphates and iron ore. This is a feature which at all times favours shippers from that area and applies with equal force to North African phosphates in relation to Florida Pebble. Here it may be remarked that whilst Moroccan phosphates appear to have enjoyed considerably cheaper freights than Spanish pyrites, with the improvement of Charter Party conditions from Huelva, notably the suppression of the 6% commission formerly taken by the suppliers, this gap should considerably lessen.

As to the future, apart from minor "boomlets" like that provoked by last summer's drought, there is no reason for the next year or two, to anticipate any great change in freight rates over those prevailing during the past two years' slump, either from Huelva or the U.S. Gulf. Until world tonnage supply is in concert with demand there is no hope of any lasting or big improvement in freights. This means that all commodities will continue to enjoy an element of subsidy in their c.i.f. prices, representing the loss of profits to shipowners. This artificial advantage must evidently be much greater in the case of Gulf sulphur than for Spanish pyrites. But, it would be very wrong to expect this state of affairs to continue for ever, and when the tide turns, shipowners will seek mainly in the longer trades to recoup the losses of the lean years. A modern motorship could trade profitably from Huelva to Rotterdam and make provision for interest, replacement and depreciation, etc., on about 27s. a ton freight, a figure not greatly in excess of the present going rate. But, whilst a similar ship trading from U.S. Gulf to the United Kingdom might just about achieve a bare break-even on 35s. a ton, this figure would need to be increased to something like an average of 55s. over the whole working life of the ship to be on a parity with 27s. from Huelva to Near Continent.

On the basis of the depressed freights of the past two years the nett f.i.o. freight element per Unit of Sulphur per ton f.a.s. Rotterdam works out at about 4.26 pence in the case of shipments ex Gulf ports, whilst the equivalent for Spanish pyrites (48% S) is almost exactly fivepence. So, on the face of it there is an apparent advantage, on freight alone, of some 6s. 2d. a ton (less than $1) in favour of sulphur. It is no part of the purpose of this article to go into the f.o.b. prices for the two commodities or the respective costs of treating them, nor can the value of pyrites residues here be considered; though with a mounting dependence of the German steel industry on burnt ore, this is a factor not to be forgotten. When freights again rise to levels profitable to shipowners the sea-transport factor per unit S will of course swing heavily in favour of pyrites. Whether, at that stage the American producers can overcome this long-term disadvantage of sulphur by shipment for example in liquid form in coiled tankers, is a matter for conjecture—and perhaps for research.

Prices and Trends

THE PROGRESSIVE INCREASE of world sulphur production capacity accentuates the weakness of the market and the underlying instability of prices. During 1959, and particularly during the closing months of the year, the level of world sulphur consumption advanced by nearly 6% to an estimated level of 16.5 million. This had no effect on the prevailing price structure nor on the prospects for the immediate future of narrowing the gap between potential supply and demand. On the contrary, production capacity in three of the four major world sources of brimstone supply —U.S.A., France and Canada—has, notwithstanding substantial increases, not yet reached its peak, and whilst the current programme of installations should establish new levels in the U.S.A. and in France this year, the Canadian by-product sulphur industry is not expected to reach this until the mid-1960's. The outstanding development is the coming on stream of Freeport Sulphur Company's offshore dome at Grand Isle, another "first" in this Company's record of outstanding feats in sulphur mining and engineering and promising to add a second multi-million ton dome to the U.S. sulphur industry. In France, the slight delay experienced in the rate of sulphur recovery plant installations at the Lacq natural gas field appears to have been made up, and the fourth and final stage which will add nearly 700,000 tonnes per annum to installed capacity and thus double it, is well advanced and expected to start operations by the end of 1960 as originally scheduled. The absence of significant expansion in Mexico does not detract from the strength of this sector of the Frasch sulphur industry or its potential impact on world supplies.

In common with U.S. and French sulphur supplies, the Mexican sulphur producers are at present making every effort to secure new outlets and customers at home and abroad. The emphasis on tonnage, as opposed to maintenance of price levels springs from the low employment of available capacity at virtually all major Frasch sulphur installations, coupled with the desire to attain a position of advantage in markets with the greatest growth potential. This competition for new custom which each major supplier is aiming to secure for periods longer than the current year, centres on the major markets outside the U.S.A., notably in Europe and British Commonwealth countries, the latter representing the largest group of brimstone users and importers. In the U.S.A. domestic producers' decision to counter aggressive selling, notably of Mexican sulphur, by retaliatory price concessions, has for the time being imposed a strained rigidity on the sulphur market. Under these conditions competitive selling could precipitate a severe drop in prices in large and sensitive marketing areas in the U.S.A. Elsewhere, notably in Europe, although less sweeping the sulphur price structure is under constant pressure and in recent months a number of new sales are reported at prices up to $2 lower than were customary early in 1959.

At the same time, European pyrites producers are trying to consolidate their markets in which low f.o.b. prices, better iron and copper values of residues, increasing introduction of roasters with heat recovery and a temporary slight advantage in relative freight costs, make sulphur in pyrites still appreciably cheaper than brimstone. The pressure of brimstone suppliers in these markets remains nevertheless strong and at present of the major sulphur users only Japan and the Communist countries, notably U.S.S.R., are outside the orbit of the highly competitive sulphur markets.

The imminence of large quantities of sulphur, notably of recovered sulphur, coming onto the market from new sources of supply, accentuates the threat to several smaller producers who have already reached the borderline of profitability, but on whose survival sulphur users depend for a choice of supplier and thereby a safeguard for the future. The

present trend of deteriorating prices is engendered largely by fear and distrust as the result of mounting competition amongst the main groups of suppliers. Their approximate balance of strength in world export markets seems to prevent the re-emergence of price leadership, which if it were pursued firmly and fairly as in the past could progressively bring back the stability and a large measure of prosperity which the industry needs.

The recent formation of The World Sulphur Institute, to promote from a technical viewpoint new outlets for sulphur, offers the most promising means of accelerating the rate of expansion of sulphur markets and of improving the imbalance between production capacity and demand. Mr. Russell Coleman, former Executive Vice-President of the National Plant Food Institute of Washington, has been appointed President of the Sulphur Institute, which will have its headquarters in the U.S.A. and a corresponding office in London.

PRICES

Brimstone

In the United States posted prices remain unchanged at $25 per ton of bright sulphur f.o.b./f.a.s. Gulf Ports, with a discount of $1 for off-colour grades and $1.50 for delivery f.o.b. mine. In effect in most regions on the Atlantic Seaboard, the Eastern and N. Central States where competition with Mexican sulphur is fierce, freight contributions of up to $3.50 and additional discounts of $1 or more are granted by U.S. producers to compete with Mexican sulphur. Delivered prices range from $24 to $26 per ton bright or acid treated sulphur. The sulphur market has at present some appearance of stability following the determined move by Freeport Sulphur Company last summer to counter any attempt by its competitors, notably the Mexican producers, to attract new custom by price concessions with similar measures in the form of freight rebates and other discounts. As a result this market, in particular in the North Central States on the Great Lakes' shores, where Mexican sulphur enters competitively by way of the St. Lawrence Seaway, is tense. Further inroads into the orbit of established custom of U.S. Frasch sulphur producers could lead to fierce price cuts, at a time when the disposal of output from new U.S. domes makes price stability very desirable.

The price listed by Mexican sulphur producers is $23.50 per ton of acid treated yellow sulphur f.o.b. Coatzacoalcos. With few exceptions, however, Mexican sulphur is offered at delivered prices incorporating substantial discounts to meet the intense competition in all markets. This primarily affects Gulf Sulphur Corporation, the smaller of the two exporters, and the latest newcomer to world markets.

Fused sulphur from Italy has been almost entirely withdrawn from export markets, as it is unable to compete. The official export price is Lire 18,000 to 19,000 (£10 5s. 0d.—£10 17s. 0d.; $29.50—$30.50) per tonne f.o.b. Sicilian ports, is adjusted by subsidies which are applied selectively only in the most favourably situated markets, notably Mediterranean and Balkan countries, and some others where Italy enjoys bilateral trading facilities.

In Japan the domestic price has remained unchanged at Yen 19,000 (£19) per tonne f.o.r. mine since its reduction early last year.

In Europe competition between the Sulphur Export Corporation selling on behalf of the U.S. Frasch sulphur industry, and the two Mexican producers Pan American Sulphur Company and Gulf Sulphur Corporation, is accentuated by a common endeavour to delay the loss of existing customers to the French recovered sulphur supplies from Lacq, which enjoy a significant freight advantage, Holland and Belgium are at the centre of the clash of interests. Notwithstanding the increase in freight charges in recent months, delivered prices as low as $24.50 per ton are reported, —a small sale of Russian sulphur to Belgium even fractionally lower—but the bulk of European brimstone imports are priced in the range of $26.50 to $28.50.

PRICE AND FREIGHT INDICATIONS (f.i.o.)—POSTED PRICES—End January, 1960

f.o.b. Country of Origin	U.K.	N.W. Europe	India	Australia
U.S.A. $24—25	(45s.) £10 7/8—11 1/4	(34s.) £10 1/4—10 5/8	(70s.) £12 1/4—12 1/2	(85s.) £12 3/4—13 1/4
Mexico $20.50—23.50 ..	(45s.) £9 1/2—10 5/8	(34s.) £9—10 1/8	(70s.) £10 3/4—12 1/8	(85s.) £11 1/2—12 7/8
Italy Lire 18,000 ..	(30s.) £12	(25s.) £11 5/8	(60s.) £13 3/8	—
Canada $23.50	(65s.) £11 5/8	(60s.) £11 3/8	(80s.) £12 3/4	(80s.) £12 3/8

The domestic price of recovered sulphur in European countries follows closely the level of import prices. Although the latter have generally weakened, their impact on indigenous supplies, mostly brimstone recovered at oil refineries, has been lessened, as in many instances domestic prices incorporate inland delivery charges, taxes, premiums for special delivery such as supplies in liquid form, etc.

In Western Germany the price level in the Ruhr and at Hamburg of domestic brimstone recovered at oil refineries and from spent oxide by Ruhrgas A.G. is DM. 115-128 per tonne plus turnover tax and handling and service charges. In Belgium and Holland recovered sulphur is sold at B. Frs. 1,400 and D.Fl. 100-105 per tonne respectively. Strong competition in Scandinavian markets, notably between U.S. Frasch and French sulphur has continued to depress prices despite much enhanced demand from the very active pulp and paper industries. In Sweden domestic supplies from Svenska Skifferolje A.B. are sold at S.Kr. 158 and Orkla sulphur imported from Norway is priced correspondingly.

The extension of Canadian recovered sulphur markets throughout British Columbia and increasingly in the Pacific and N.W. States has widened the price range which remains, however, based on $23-$25 f.o.r. recovery plant. No deliveries have yet entered the nearest major market, the Great Lakes' area, where at current rail rates Canadian recovered sulphur is at an apparent freight disadvantage of $9-$10 per short ton compared with corresponding freight charges from the Gulf.

Pyrites

The general price level of European pyrites which was established on the 1st October, 1959, remains unchanged. The price for Spanish and Portuguese crude fines pyrites is based on 60s. per tonne f.o.b. for all values. The export value of Cypriot pyrites has declined to 57s. in November. With the strong upward movement of copper prices and the improved demand for purple ore in common with iron ores, residues values have improved and appear to have reached again 80s.-85s. per tonne. Non-cupreous residues have also risen in value and good quality material is quoted at 75s. f.o.barge Rotterdam.

Probably the most significant factor influencing the future of pyrites prices has been the remarkable recovery of the Spanish economy since the devaluation of the peseta last summer and the institution of measures to stabilise the economy. These appear to have met with a large measure of success and it is reported that after an initial rise, prices have stabilised and that in consequence the pressure on the pyrites mining companies of labour costs, overheads, and social charges has not increased. The present low price of 60s. per tonne of pyrites still appears to permit a reasonable profit margin and the Spanish pyrites producers, who hold the rôle of price leaders to the European industry, view the immediate future and their ability to remain competitive with a measure of confidence.

SUPPLY

Brimstone

In the United States production of Frasch sulphur rose steeply in the closing months of the year, and total output in 1959 exceeded 4.5 million tons ; the high level of consumption entailed the withdrawal of about 650,000 tons from stockpiles. Imports from Mexico and Canada at 650,000 tons and recovered

sulphur supplies of about 651,000 tons were the highest on record. It is estimated that following the closure of Bay St. Elaine Dome, but as yet excluding the Grand Isle operations, the current level of output necessitates the employment of about 70% of installed Frasch sulphur capacity. The level of stocks is approximately 3.8 million tons.

In Mexico Frasch sulphur output remains at an annual rate of about 1.3 million tons of which Pan American Sulphur Company, operating at only about 60% of installed capacity, accounts for over 800,000 tons per annum. Output of up to 500 tons per day is reported from the Texistipec Dome of Texas International Sulphur Company. Now that the Gulf Sulphur Corporation also has acid treatment facilities, more than one-third of total shipments from Mexico are in this form and the balance is filtered; no dark sulphur is now being shipped. Producers' stocks continue mounting, mainly due to the continued stockpiling of the entire output of Texas Gulf Sulphur Company's Nopalapa Dome, and now exceed one million tons. Domestic consumption is rising and this now affords a growing outlet for the Mexican Frasch sulphur industry.

Fused sulphur production in Italy is now reduced to an annual rate of little over 100,000 tonnes; stocks of this material have increased slightly to about 235,000 tonnes at the end of 1959. More sulphur concentrates and sulphur ore is being taken into domestic consumption.

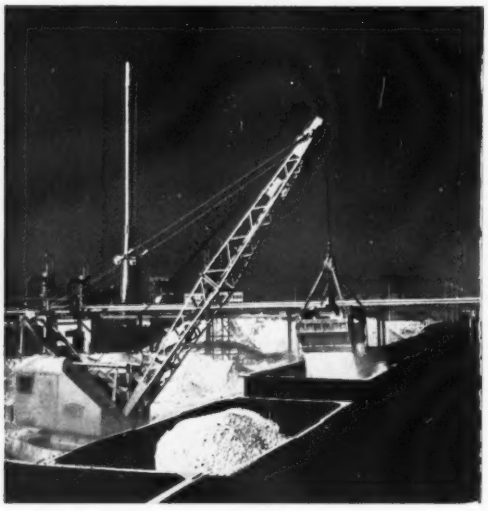
In Japan greater demand by viscose and pulp industries is reflected in higher sulphur production which is estimated to have risen to an annual rate of 230,000 tonnes. In the Argentine production of fused sulphur from native ores by Sominar S.A., employing a plant built by Chemical Construction Company of New York which combines autoclaving and flotation, is reported to be satisfactory and output of up to 50 tons daily has significantly reduced the country's import needs. Steady progress is reported from the sulphur ore mining and refining operations in South-East Poland where this year production is to be raised to 100,000 tons. Brimstone output in the U.S.S.R., officially reported at 200,000 tons in 1958, is believed to continue at the same rate and reports of several hundred thousand tonnes of brimstone being available for sale are considered to be without foundation. Widespread offers of Russian sulphur are currently being made throughout W. Europe, including London, but quantities are generally a few thousand tonnes. Brimstone delivered by the U.S.S.R. to India early last year was of good quality, averaging 99.2% S. Under the trade agreement with Finland concluded in November of last year, the U.S.S.R. undertakes to deliver in 1961 some 12,000 tonnes sulphur and it is foreseen that this quantity should increase to 20,000 tonnes annually by 1965.

Recovered Sulphur

Recovered sulphur production in the U.S.A. has in recent months failed to regain the high levels prevailing earlier in 1959, which was about 10% higher than current output of around 52,000 tons monthly. Nevertheless, new capacity is being added constantly notably at oil refineries. Of the new sulphur recovery plants at gas fields, that of Tidewater Oil Company at New Hope, Smackover, a 224 tons per day plant, is the largest at present under construction in the United States.

In Canada recovered sulphur output is increasing slowly. Last year's output of about 300,000 short tons is likely to be doubled this year, but even this would be no more than about 60% of output forecast a year or two ago. A significant addition to production capacity is the recovery plant at the Sudbury smelter of International Nickel Company, where jointly with Texas Gulf Sulphur a new reduction process of sulphur dioxide in nickel smelter gases has been developed, using natural gas and fuel oil as reducing agent. In view of the world sulphur surplus and unstable prices, no decision has been reached on the date of starting or the level of operation of the plant. Of the new sulphur recovery operations from natural gas cleaning the output of up to 370 short tons daily unit of Texas Gulf Sulphur

Co. at Okotoks continues to be stockpiled. Following the much publicised formation of the Alberta Pacific Sulphur Company which announced its intention to produce 700,000 tons per annum sulphur at the Panther River gas fields, some doubts are reported as to the reality of the project. The exploitation appears to entail virtually sulphur production only, since it is to be based on wells containing predominately H_2S—one as much as 87% H_2S. The lack of significant saleable cleansed



Loading sulphur at Lacq.

natural gas supplies from the operation deprives it of an essential source of revenue, whilst prevailing conditions and prices in the world sulphur market hold out little prospect of initial profitability from sulphur alone. In the absence of fuller details from the directors amongst whom Mr. M. A. S. Makris, formerly of Texas International Sulphur Company, is recognised to be well versed in sulphur affairs, it is difficult to assess the project in its true light.

During 1959 Société Nationale des Pétroles d'Aquitaine recovered 426,486 tonnes high purity brimstone. Of this 165,290 tonnes was delivered to the home market and exports totalled 217,480 tonnes. The balance was added to stocks at Lacq and at Bayonne, which at 31st December, 1959, totalled about 70,000 tonnes. Current production is close to the rated installed capacity of 600,000 tonnes per annum. By April it is expected that the first part of Stage IV will be completed and that by the end of the year full capacity will be available. This will permit daily throughput of 20 million metres of natural gas and the recovery of over 4,000 tonnes brimstone.

Sulphur recovery at the Swedish shale oil works at Kvarntorp was the highest on record in 1959 when it totalled 35,000 tonnes. It was wholly delivered to the booming domestic pulp and paper industries.

In Bulgaria a major coal and fertilizer project has been initiated at Stara Zagora where by 1962 coal gasification is to yield some 15,000 tonnes recovered sulphur. At present output from a similar operation at the country's only nitrogen fertiliser plant at Dimitrovgrad is believed to amount to 5,000-8,000 tonnes brimstone.

In Japan a second sulphur recovery plant is projected at an oil refinery. Its output, believed to be rated at 10,000 tons per annum, will treble recovered sulphur output in Japan.

World production of brimstone in 1959 is estimated as follows :

	1959	1958	Change
	Thousand Tons		
Frasch Sulphur ...	5,820	5,847	− ½%
Recovered Sulphur*	1,820	1,337	+36%
Native Sulphur† ...	410	429	−4½%
Total	8,050	7,613	+5½%

* Including brimstone recovered by the Orkla Process

† Excluding crude ore and concentrates

Pyrites

The intensity of sulphuric acid demand in Western Europe during the closing months of the year was reflected in improved delivery results by all European pyrites producers. Cyprus for the first time appears to have become the world's largest exporter of pyrites, although the estimated total in 1959 of 1 million tons shows little change from the pre-

ceding year. The severe setback in export markets suffered by the Spanish pyrites mines early in 1959 adversely affected the year-end position. It is reported that exports totalled about 950,000 tonnes, of which Cia Rio Tinto Limitada accounted for 480,000 tonnes and the Tharsis Sulphur and Copper Company for 350,000 tonnes. Production and exports of by-product pyrites concentrates from Yugoslavia are growing. Amongst others, under a new trade agreement with Poland increased deliveries are foreseen. A new pyrite deposit, sixty miles south of Belgrade is being developed and the output is destined for export.

In Norway A/S Røros Kobberverk has completed an aerial survey of its mining property and drilling is progressing to prove a pyrite ore body that was discovered.

Consumption in all major pyrites producing countries has advanced and been maintained at satisfactory levels. The largest expansion of domestic demand is recorded in Spain, Portugal and Japan where sulphuric acid demand continues to advance, while in Scandinavia, notably in Sweden, the recovery of the pulp industry has boosted sulphur demand in the closing months of the year to the peak levels of 2 to 3 years ago. World consumption in 1959 is estimated to have totalled 5.9 million tons of sulphur in pyrites, 4% more than in 1958, but world trade in pyrites which, with the exception of Canadian exports to U.S.A., is virtually confined to Europe has shrunk about 3%.

FREIGHTS

The effect on ocean freight rates of last autumn's increased demand for space for grain shipments has been more prolonged than was anticipated in chartering circles. The voyage index of the U.K. Chamber of Shipping (1952=100) which had risen steeply in the early autumn stood at the end of the year at 82.5. The higher level of freight rates had affected equally transatlantic sulphur freights and the ore trade from the Mediterranean. The highest proportionate increase appears to occur in the rates for brimstone from Bayonne. The rate from the Gulf of Mexico to the U.K. advanced to 52s. 6d. for liners and tramps, and that to the Continent to $5.20 to $5.50. At these rates, even if reduced to f.i.o. terms, the premium for inducing vessels to call in U.K. ports appears to have increased. From Bayonne to the U.K. the rate is now based on 25s. f.i.o. and that to the N.W. European ports is reported at 21s. f.i.o. Pyrites charters from Huelva to the Antwerp/Rotterdam range rose in excess of 30s. in the customary end-of-year rush to complete contracts and has since fallen back to 26s. (2s. loading and 2s. 6d./2s. discharge) about the same as the reported level of the long term chartering arrangements for German pyrites imports. From Cyprus to N.W. Europe rates have not risen by quite the same margin and are now reported at 29s. 6d. ; the corresponding rate from Morphou Bay to the U.K. is now reported at 40s.

An important concession was recently made by the Spanish Pyrites Producers in foregoing the benefit of 6% of freight which they used to receive as shippers under the terms of the Charter Party. As a result buyers should be able to secure freights at about 1s. 6d. per ton cheaper and also be able to attract more shipping to this trade which shipowners, on account of the heavy aggregate brokerage fees, did not always favour.

Rates from the U.S. Gulf to India after having hardened in December to about $12 are now reported at $9.25-$10. Those to Australia fluctuate near $12-$13.50 f.i.o. Since October to December when the peak of the freight boomlet was reached, freight rates have eased but in the sulphur trade they are still 12-16% higher than one year ago. The current level of freights which is sustained by increased demand for seasonal sugar shipments and the higher rate of iron ore deliveries is not expected to weaken, except possibly in respect of the rates from the Gulf, until the usual falling off of demand in mid-summer.

United States Sulphur

Frasch Sulphur

Production of Frasch sulphur during the 3rd quarter 1959 totalled 1,085,910 tons, virtually no change from the low level of activity during the two previous quarters, although compared with the third quarter of 1958, output had risen slightly—3% or 35,000 tons. The nine months' total of only 3,251,000 tons clearly shows the effect of the severe restriction on output but their subsequent relaxation in response to heavy consumer demand raised the year-end total for 1959 to just over 4.5 million tons.

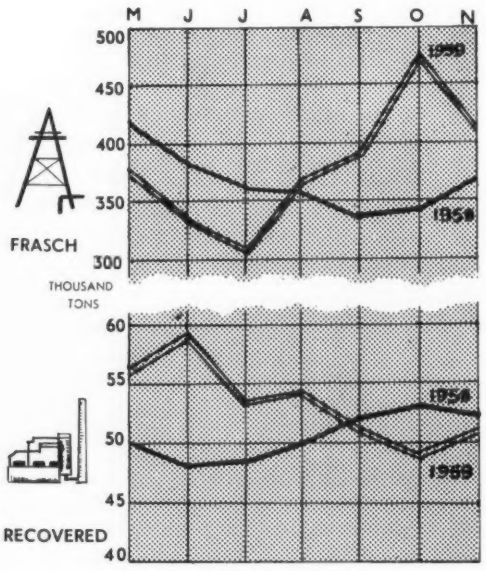


Fig. 2. Monthly Production.

There were no significant changes during the third quarter in the activities of individual domes; in November, however, the Freeport Sulphur Company's Bay St. Elaine dome was finally exhausted and closed down, having produced in the course of seven years' operation 1,113,000 tons brimstone.

Apparent sales of Frasch sulphur during the third quarter were 1,349,785 tons, 290,000 tons more than the corresponding quarter last year, and the cumulative total up to the end of September, 1959, was 3,877,670 tons, compared with 3,328,501 tons in 1958. This marked advance in sales in 1959 reflects the return of industrial prosperity in the United States—despite the steel and copper strikes—and at the same time export sales of Frasch sulphur were being maintained almost at the record levels achieved in 1956.

Throughout this period stocks steadily decreased and at the end of September, totalling 3,814,932 tons, stocks of Frasch sulphur were one million tons less than they were one year earlier.

Recovered Sulphur

Production of brimstone from oil refinery and natural gas cleaning installations totalled 159,762 tons during the third quarter, a decline of nearly 5,000 tons compared with results of the previous three months. Despite the large number of sulphur recovery plants that have been installed over the past eighteen months, this fall in production was not wholly unexpected in view of the restrictions on imported crude oil reducing the volume of sour Middle East crude entering refineries.

The recently completed plants of Consolidated Chemical Industries Ltd. at Baytown, Texas, and Allied Chemical & Dye Corporation at Richmond, California, are reported to be operating satisfactorily. Additional sulphur recovery capacity of about 200,000 tons is planned for erection during 1960. The principal plants being erected are for Tidewater Oil Company where Brown & Root are building a unit to recover brimstone from natural gas at the New Hope, Smackover field, with a daily capacity of 224 long tons, while Stauffer Chemical Company is installing a major plant at Delaware City in conjunction with its new production of carbon disulphide by the liquid sulphur/methane process. Other smaller plants

are planned by Union Oil Co. of California at their Wilmington Refinery and by Pan American Petroleum Corp. The engineering division of the latter is installing a plant of its own design at the Abo Field ; it will have a capacity of 12½ tons per day and is scheduled to be operating by the summer of this year.

It is of interest to note that when plants under construction are in production there will be four plants with capacities in excess of 200 tons sulphur per day and seven plants with daily capacities between 100 and 200 tons brimstone.

Apparent sales of recovered sulphur in the third quarter totalled 168,462 tons, a decline of nearly 11,000 tons compared with

Socony Mobil Oil Co. General view of the sulphur recovery plant at the Paulsboro refinery. The plant has a daily capacity of 100 *short tons and was built by the Badger Manufacturing Co.*

the previous quarter and 4,000 tons less than in the corresponding period last year. In general this market has remained stable, largely due to the existence of regular contracts for this material which are geared to production to meet the producers' desire not to create excessive stockpiles. Stable sales outlets, coupled with the fall in production during the third quarter caused recovered sulphur stocks to decline 9,000 tons ; at the end of September they totalled 154,211 tons.

Consumption

In response to the high level of industrial activity, deliveries of domestically produced and imported sulphur continued at a substantially higher rate than in the previous year. Deliveries in the third quarter are estimated at 1.2 million tons, compared with only one million tons a year ago and deliveries for the first nine months of 1959 totalling 3.75 million tons represented an increase of 23% over the same period in 1958. Although Mexican imports increased in volume, their percentage share of the market has declined from 16% to 15% in the same period. The consumption of pyrites and spent alkylation acid for sulphuric acid production has remained steady while the strikes and difficulties in the non-ferrous metals sector severely restricted the throughput of zinc and copper concentrates with the consequent loss of by-product acid. With the exception of the iron and copper industries, demand for sulphuric acid has been at record levels which accounted for the increased demand for brimstone. In the non-acid sector brimstone requirements also rose to record levels notably in paper, viscose rayon and transparent paper manufacture. Intense competition between rayon and nylon for the new and replacement motor-car tyre market has resulted in impressive reductions in the cost of each material but the recognized properties of " tyrex " appears to have secured a large part of this outlet for the viscose rayon industry. The present developments in food and general merchandise packaging has given an important fillip to the growth of transparent paper production. In 1959 production of this is estimated at 435 million lbs.—8% more than in 1958—and it is expected to rise by at least 20 million lbs. in the current year. The American Viscose Corporation, who are the second largest manufacturers of transparent

paper in the world, have an annual capacity of 150 million lbs. Their plant at Fredericksburg, Va., is reported to be the largest single unit built, while at their Marcus Hook, Pa., plant the company is planning to increase production as soon as possible. This industry represents a significant outlet for both Frasch and recovered sulphur and as such is of growing interest to sulphur producers.

Sulphuric Acid

Production of sulphuric acid during the third quarter totalled 4.01 million short tons, compared to 3.72 million in the corresponding period of last year. Individual monthly data is as follows :—

	July	August	Sept.
1959 Gross Total ...	1,365,098	1,310,875	1,332,794
Chamber ...	132,803	120,864	132,006
Contact ...	1,232,295	1,190,011	1,200,788
Spent Acid ...	59,013	61,991	57,987
1958 Gross Total ...	1,218,222	1,242,105	1,262,589
Chamber ...	92,983	91,141	109,781
Contact ...	1,125,239	1,150,964	1,152,808
Spent Acid ...	51,655	61,085	51,527

Total new acid production for the first nine months reached the record total of 13.02 million short tons despite the absence of demand from the steel industry in terms of pickling acid and acid for by-product ammonium sulphate production.

Some of the most important sulphuric acid projects which were completed in 1959 were those based on the decomposition of sludge acids which arise at alkylation units in oil refineries ; their large capacity alone makes them prominent. Stauffer Chemical Co.'s plant at Whiting, Indiana, has an annual acid capacity of one-quarter million tons (100% H_2SO_4) while the plant commissioned by Dixon Chemicals at Paulsboro', New Jersey, is the largest acid plant in the world based on sludge acid with an annual capacity of one-half million tons (100% H_2SO_4). Important additions to plant capacity were made in the North-west States : at Pocatello, Idaho, a 400 tons per day brimstone burning plant of the J. R. Simplot Co. will meet the needs of phosphoric acid manufacture ; the 200 tons per day plant of the North Star Chemical Co. came on stream in October at St. Paul, Minnesota ; this has been designed to permit an expansion of 25% so that sludge acid can be used which will arise from the alkylation unit, when completed, at the adjacent oil refinery of the Great Northern Oil Co.

With the exception of demand from the steel industry, which was strike bound, all industries consuming sulphuric acid appear to have consolidated the results which were obtained in the early months of 1959 and in many cases, their requirements have considerably expanded. The fertilizer industry has contributed significantly to the increased consumption and superphosphates in particular had a record year. Most important in this sector was the increased demand for " wet process " phosphoric acid manufacture ; although triple superphosphate output failed to advance, wet process acid use in complexes and increasingly for other uses, called for large volumes of sulphuric acid. Viscose rayon and transparent paper provided an expanding outlet for sulphuric acid and estimates of consumption for 1959 are about one million tons. Manufacture of titanium dioxide and uranium oxide has needed additional acid requirements as new capacity for these new industrial raw materials has been brought into operation. An important " growth " industry for acid use in the past three years has been that of aluminium sulphate. Production of this material in 1959 is estimated at about 900,000 tons and is directed to paper makers and to private utilities for water purification. Plans have been announced for the installation of additional " alum " facilities. Operating twenty-eight "alum" producing units, the General Chemical Division of the Allied Chemical & Dye Corporation of New York dominates the industry and it has announced that the twenty-ninth plant is now being built at El Segundo, Calif. Stauffer Chemical Company, operating five alum plants, are installing a new plant at Vernon, California, and it is due to commence operations this year. Also in California is the Associated Chemical Co. at Pomona. Formed early in 1959 primarily to manufacture alum,

the company planned to instal plant with an annual capacity of 10,000 tons liquid alum and which was to be in operation by 1960 but no further details are known. Hydrofluoric acid manufacture was another sector of the chemical industry which increased its sulphuric acid requirements. The gain in this sector is however two-edged as some of the new end-uses of hydrofluoric acid displace sulphuric acid.

Trade

United States imports of brimstone from Mexico continued to increase in 1959 and in the first nine months imports from Mexico totalled 520,507 tons, an increase of 132,000 tons compared with the corresponding period last year. Imports from Canada began to assume importance and it is estimated that in the period January to September, about 15,000 tons were imported into the Pacific North-west.

Exports of crude sulphur during the third quarter were at record levels and at 499,794 tons, showed an increase of 33% compared with the corresponding period last year. The nine monthly total for 1959 was 1,189,054 tons, an increase of 4%. Preliminary figures for the whole of 1959 indicate that total exports were slightly in excess of 1.6 million tons. Table II sets out the pattern of trade :—

TABLE II

	1959	1958	Change	Change
	000 tons		000 tons	%
Canada ...	305	332	−27	− 8
Central America	40	17	+23	+135
South America	180	141	+39	+ 28
Asia	145	129	+16	+ 12
Europe ...	640	673	−33	− 5
N. Africa ...	33	36	− 3	− 8
S. Africa ...	50	66	−16	− 24
Middle East ...	31	17	+14	+ 82
Australasia ...	182	164	+18	+ 11
Total ...	1,606	1,575	+31	+ 2

The most important gains were made in Cuba, Brazil, Netherlands, Tunisia, Israel and

Aerial view of sulphur storage vats and new shipping facilities under construction at Texas Gulf Sulphur's Beaumont Docks.

PYRITES

a stable, assured and competitive source of sulphur

The Rio Tinto and Tharsis mines in Spain have supplied Pyrites for over eighty years——Their known reserves are unrivalled

COMPAÑIA ESPAÑOLA de MINAS de RIO TINTO S.A.
THE THARSIS SULPHUR AND COPPER CO. LTD.

New Zealand—areas where demand for brimstone and sulphuric acid is booming, while losses in Canada, Europe generally, and Australia are attributed to intensive competition from domestic producers, as well as from Mexican and French supplies. In the case of North Africa, political troubles reduced the requirements of Algeria, while to Tunisia some 16,000 tons were shipped compared with none in 1958; shipments to Morocco ceased.

Exports to Central and South America are dominated by Brazil (130,000 tons) and Argentina and Cuba (33,000 tons each). This area is an important "growth" area and despite the competition from Mexican suppliers for the first time, exports to these three countries increased by 55,000 tons in 1959. The European market is more complex in view of French and Mexican supplies; however, the United Kingdom remains the king-pin as it takes about 40% of the 640,000 tons of U.S. sulphur delivered to Europe; actual deliveries to the United Kingdom in 1959 are estimated to have totalled 265,000 tons—a decrease of 14,000 tons compared with 1958. Increased shipments were reported to West Germany (+18,000 tons) and to the Netherlands (+26,000 tons) where it displaced Mexican sulphur. An important new market is Poland and Czechoslovakia and about 30,000 tons were consigned to these destinations.

In 1959 Israel increased her requisitions of U.S. sulphur to 25,000 tons, about one half of the total imports into that country. Exports to Australasia increased by 11% but this total masks the decline of deliveries to Australia of 9,000 tons to 115,000 tons and to New Zealand the rise of 27,000 tons to 67,000 tons.

Outlook

The already high levels of sulphur consumption in the latter half of 1959 were further advanced after the settlement of the steel and copper strikes and it is estimated that consumption of sulphur in all forms reached a record total of six million tons in 1959. The pressure on brimstone supplies both for export and domestic markets, has resulted in the depletion of the stockpile by about 650,000 tons throughout the year to 3.8 million tons. The record level of industrial activity has been reflected in the demand for sulphuric acid and "gross" production of this is estimated to have totalled 17.4 million short tons, an increase of 9% over 1958; this includes 16.7 million tons of "new" acid, an increase of 10%. During 1959 about 1 million tons of new acid capacity was brought into operation bringing the total installed capacity at the end of December to 22.6 million short tons.

The buoyancy of industry is expected to boost brimstone demand in 1960 in both the acid and non-acid sectors. Already several major acid projects have been announced which will further raise installed capacity by over 400,000 tons annually. The principal projects reported are for the Davison Chemical Company who are to instal a 400 tons per day Leonard-Monsanto plant at Bartow, Florida; the Du Pont Company are installing a major plant at Houston, Texas, as part of their modernisation programme; this will supply acid to a caprolactam plant which the company are building at Beaumont, Texas, in addition to local sales in the Gulf coast; Pittsburgh Coke & Chemical Co. are expanding their sulphuric acid plant at Neville Island by 75% to 72,000 tons per annum. On the West Coast, Collier Carbon are to instal a 250 tons per day plant at Wilmington, California, based on locally available supplies of hydrogen sulphide, recovered brimstone and sludge acids.

In the non-acid sector, sulphur consumption is expected to be maintained if not increased, with strong demand from the pulp, rayon and transparent paper and rubber industries. Despite the instability and weakness of sulphur prices, especially in the principal consuming areas, Frasch sulphur producers can be well pleased with these prospects, although the present excessive capacity in this area will be further increased with the commencement of operations of Freeport Sulphur Company's Grand Isle Dome.

SULPHUR IN MEXICO

In 1954 the only sulphur produced in Mexico consisted of small quantities of recovered and volcanic sulphur to supplement which imports of brimstone were needed. Four years later Mexican exports of Frasch sulphur exceeded one million tons and as an exporter she came second only to the United States. In comparison with the results of these remarkable years those of 1959 appear subdued. Total production increased by 8% : but exports fell somewhat by 4% ; and deliveries to the home market increased by 28%. Now that the Mexican Frasch sulphur industry has grown to maturity it is in turn being subjected to competition from newcomers to the world sulphur markets—at present the producers of recovered sulphur in France, and at a later date those of recovered sulphur in Canada.

A comparison of the supply and demand for Mexican sulphur in 1958 and 1959 is given below :—

000 tons.	Frasch	Recovered	Native	Total
Production	1,289 (+7%)	70 (+37%)	18 (−5%)	1,377 (+8%)
Total deliveries	1,060 (−2%)	69 (+15%)	18 (− %)	1,147 (−1%)
Exports	1,030 (−4%)	—	—	1,030 (−4%)
Domestic Sales	35 (+150%)	69 (+15%)	18 (− %)	122 (+34%)
Addition to Stock	227	1	—	228
Stocks at 31/12/59	1,033 (+28%)	No data		c. 1.03 million tons (+28%)

From this it will be seen that stock accumulation in 1959 was considerably greater than that of 1958. Total stocks now stand at more than one million tons.

PRODUCTION

The final figures indicate little change in the relative importance to total output of the three sources of supply—Frasch production, recovered sulphur, and brimstone extracted from native ores. Nevertheless the output and sales of the two major Frasch producers—who remain the only exporters—do indicate differing trends. Both companies increased their production, stocks, and sales to the domestic market, but while the larger of the two, the Pan American Sulphur Company, increased its sales to the export market, the Gulf Sulphur Company exported less than in the previous year. Moreover the Pan American Sulphur Company claimed by far the larger share of the expansion of the domestic market.

Frasch Sulphur

Pan American Sulphur Company. 1959 was a somewhat better year than its predecessor :—

	1958	1959	Change	
	000 tons.			%
Production	822	887	+65	+8
Total Deliveries	810	856	+46	+6
Exports	797	830	+33	+4
Domestic sales	13	31	+18	+138
Stocks	549	580	+31	+5

Nevertheless the advance was less rapid than that of 1958. Whereas the 1958 production and sales figures exceeded those of 1957 by 14% and 19% respectively, the 1959 production and sales figures exceeded those of 1958 by only 8% and 6% respectively.

In the course of the year the company completed its liquid sulphur terminal at Tampa in Florida through which some 600 tons of molten sulphur are run daily. A 1,000 tons liquid storage tank and sulphur filtration equipment are also being installed. Dry bulk storage facilities with an approximate capacity

of 40,000 to 50,000 tons are expected to be completed in the March of this year. The company furthermore continued its programme for quality improvement and is at the moment producing about 1,000 tons a day of special bright sulphur exceeding 99.9% in purity. To expand output of this material it has been decided to instal in 1960 a 15 tons per day sulphuric acid plant. This will be built by the

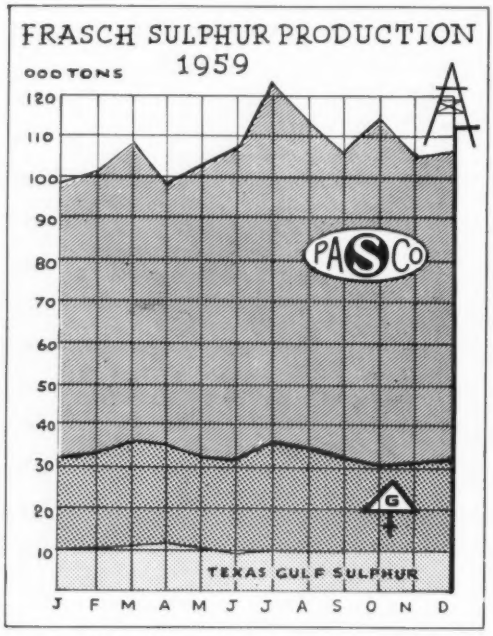


Fig. 3. Monthly production of Frasch Sulphur in 1959.

Pan American Consulting Company Inc. of Reisterstown in Maryland to the Leonard-Monsanto design. All the acid will be used for sulphur purification. Although economy in operating costs is the main reason for having the plant, a programme has been planned which it is hoped will be of value to the sulphuric acid industry in general. Engineering data is to be developed on mass transfer characteristics in the drying and absorption phases, catalyst degradation and vanadium migration in the converter, and factors contributing to stack mist. The company hopes to be able to evaluate some of the newer methods of stack mist control. The ready availability of various qualities of sulphur and the size of the sulphuric acid plant should facilitate these investigations.

The President, Mr. Harry C. Webb, is optimistic about the current year. Shipments in January were higher than in any other month in the company's history and it now appears that the whole of the first quarter will establish a similar record.

Gulf Sulphur Corporation. The company's principal achievement was the creation of a substantial stockpile whereby many of the anxieties of past years in adhering to delivery schedules have been removed :—

	1958	1959	Change	
		000 tons.		%
Production	263	282	+19	+ 7
Total Deliveries ...	269	204	−65	−24
Exports	268	200	−68	−26
Domestic sales ...	1	4	+ 3	+300
Stocks	27	103	+76	+281

This picture differs considerably from that of the previous year. The company's production in 1958 exceeded that of 1957 by 47%—yet in that year shipments exceeded production and stocks were subject to a continuous drain. The company's production in 1959 exceeded that of 1958 by only 7%. At the same time total shipments fell by 24%. As with the Pan American Sulphur Company, increasing emphasis is being laid on the production of acid-treated bright sulphur.

Texas Gulf Sulphur Company. Production at the Nopalapa dome slightly exceeded that of 1958 and the entire output was again stockpiled :—

	1958	1959	Change	
		000 tons.		%
Production	115	120	+5	+4
Stocks	230	350	+120	+52

Texas International Sulphur Company. It appears that although the Texistipec Dome was heated and tests on it begun in 1959, no significant quantity of sulphur was in fact produced. It is however thought that the dome has now come on stream and in January, 1960,

produced some 500 tons of sulphur from two out of four wells. It is rumoured that the company has completed 14 additional wells of which four are to be steamed for production as soon as technical conditions will permit.

Recovered Sulphur

Petroleos Mexicanos. The output of recovered sulphur exceeded that of 1958. Apart from a small quantity which went to stocks the entire production was sold to the home market :—

	1958	1959	Change	
	000 tons.			%
Production	51	70	+19	+37
Domestic sales ...	60	69	+ 9	+15
Addition to stocks	−9	+1	+10	+110
Stocks at 31/12/59 ...	*	*	*	*

* No data

By far the greater part of the output of recovered sulphur was contributed by the 120 tons per day Poza Rica natural gas plant, but a significant amount came from a 25 tons per day plant at the Mexico City oil refinery, which came on stream in the course of the year. A 20 tons per day plant at the Tampico refinery

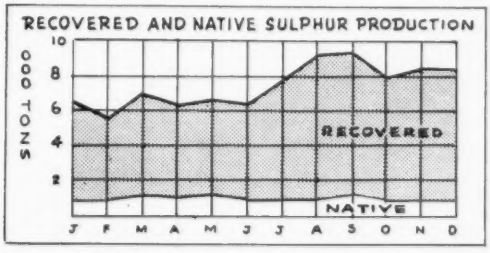


Fig. 4. Monthly production of Recovered and Native sulphur in 1959.

is thought either to have come on stream or to be shortly about to do so. Nevertheless no significant increase in the production of recovered sulphur is now expected till the end of 1962, when the oil industry's expansion plans for the treatment of almost double the present volume of sour gas will have been realised. In 1963 Pemex should produce between 12,000 and 15,000 tons of sulphur per month as opposed to the current monthly average of 7,000 tons.

Sulphur from Native Ores

Negociacion Minera S.A. The operations of the surface mines produced slightly less sulphur than in the previous year. Their entire output was sold to domestic consumers :—

	1958	1959	Change	
	000 tons.			%
Production ...	19	18	−1	−5
Domestic sales ...	18	18	0	0
Addition to stocks	+1	0	−1	−100
Stocks at 31/12/59	*	*	*	*

* No data

EXPORTS

In 1959 Mexican sulphur exports fell a little, the total figure being slightly in excess of one million tons. While sales in some markets were lost to the French, in other markets the Mexicans made notable gains over their results in 1958. Losses to Europe, to Australia, and to North Africa and the Middle East were compensated for by gains to South America, North America, S. Africa and Asia:—

	1958	1959	Change
	000 tons.		
Europe	235.7	198.5	−37.2
North Africa and Middle East ...	68.8	46.0	−22.8
Australasia	89.6	59.0	−30.6
North America ...	611.7	623.3	+11.6
South America ...	—	15.3	+15.3
South Africa ...	55.3	59.5	+ 4.2
Asia	4.0	24.3	+20.3
	1,065.1	1,030.9	−34.2

Europe was naturally the area to which shipments fell most. Nevertheless even in Europe exports fell to three countries only—France, the Netherlands and West Germany. Exports to the U.K., the world's second largest importer of brimstone, to Belgium and to Austria all rose significantly, and sales were made to Switzerland and Yugoslavia for the first time :—

Europe	1958	1959	Change
		000 tons.	
France	115.7	55.3	−60.4
U.K.	58.8	71.6	+12.8
Yugoslavia ...	—	2.8	+ 2.8
Switzerland ...	—	1.8	+ 1.8
Sweden	3.2	5.7	+ 2.5
W. Germany ...	10.8	9.5	− 1.3
Netherlands ..	35.7	6.0	−29.7
Austria	0.5	9.3	+ 8.8
Belgium	11.0	36.5	+25.5
	235.7	198.5	−37.2

Sales to Australasia declined owing to a fall in imports by Australia, brought about by a temporary depletion of consumer stocks. New Zealand increased her imports of Mexican sulphur :—

Australasia	1958	1959	Change
		000 tons.	
Australia ...	75.9	37.4	−38.5
New Zealand ...	13.7	21.6	+ 7.9
	89.6	59.0	−30.6

In the area classified as North Africa and the Middle East the only gain was a small shipment to Morocco, the first Mexican sale of sulphur to that country :—

North Africa & Middle East	1958	1959	Change
		000 tons.	
Tunisia	32.6	21.5	−11.1
Israel	36.2	23.5	−12.7
Morocco ...	—	1.0	+ 1.0
	68.8	46.0	−22.8

North America contains the first and third largest importers of sulphur in the world—the U.S.A. and Canada. While imports of sulphur by the U.S.A. are supplied exclusively by Mexico, imports of sulphur by Canada come almost entirely from the U.S.A. Mexican exports to the U.S.A. increased very slightly and a somewhat larger tonnage was supplied to Canada :—

North America	1958	1959	Change
		000 tons.	
U.S.A.	610.7	619.0	+ 8.3
Canada	1.0	4.3	+ 3.3
	611.7	623.3	+11.6

Of greater significance were the increased exports both to South America and to Asia:—

South America	1958	1959	Change
		000 tons.	
Argentina ...	—	13.6	+13.6
Peru	—	1.7	+ 1.7
		15.3	+15.3
Asia			
India	—	24.3	+24.3
Formosa	4.0	—	− 4.0
	4.0	24.3	+20.3

On account of her geographical position Mexico is well suited to supply South America, although shipping facilities from Coatzacoalcos are not as yet as favourable as those from U.S. Gulf ports.

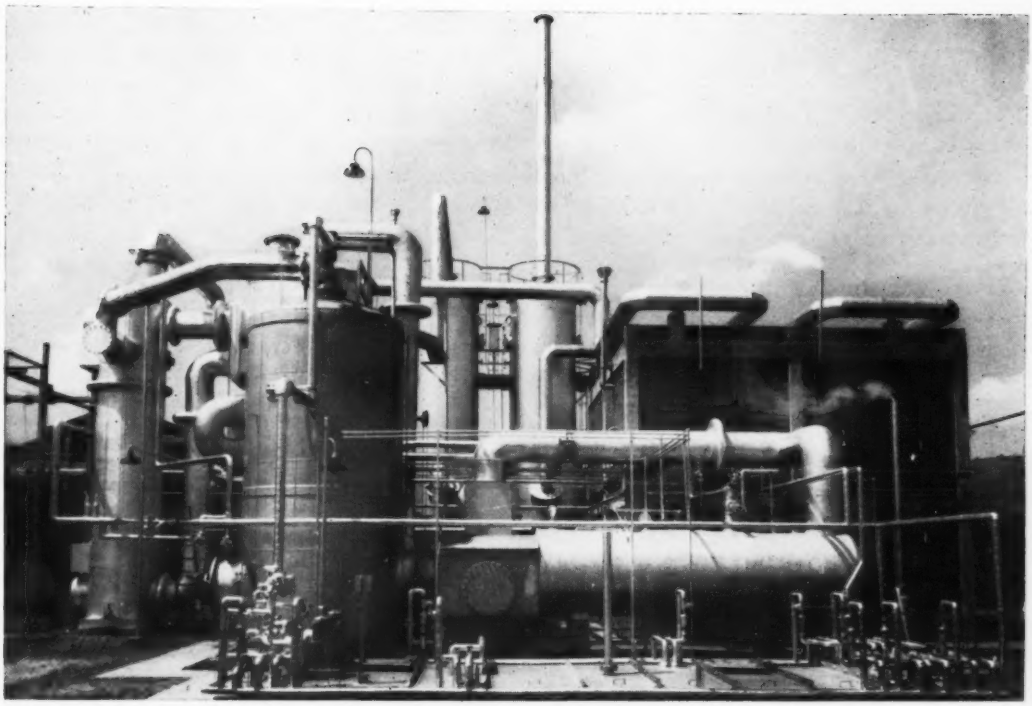
Domestic Sales

While most of the total domestic demand was as usual met with recovered sulphur, the greater part of the addition to domestic demand was met with Frasch sulphur :—

	1958	1959	Change
		000 tons.	
Frasch	13	30	+17
Recovered	60	69	+ 9
Native	18	18	—
	91	117	+26

In the next three years most of the expansions to domestic demand are likely to be met by the Frasch producers. However this is unlikely to continue when at the end of 1962 the planned 60,000 to 90,000 tons per annum increase in the rate of recovered sulphur output comes about.

Behind the expanding domestic market for sulphur there is in addition to the higher level of business activity a significant development of the Mexican economy itself. Fertilizer production is increasing. Last year a 150 tons per day brimstone plant was commissioned by the Pan American Consulting Company Inc. at the Coatzacoalcos works of Guanos y Fertilizantes de Mexico S.A. This company also buys acid from Acidos Asarco S.A. whose plant at St. Louis was converted to sulphur from lead smelter gases and its capacity doubled to about 2,000 tons per month. Acidos Asarco is a subsidiary of the American Smelting and Refining Company. The rayon industry is expanding. Both Celanese Mexicana S.A. and Celulosa y Derivados are now making rayon tyre yarn. Output by the iron and steel industries is growing and a rubber industry is being established. In the April of 1960 a 50 tons per day sulphuric acid plant is to be commissioned by Simon-Carves Ltd. for the subsidiary of Du Pont S.A. de C.V., Pigmentos y Productos Quimicos S.A., which is to be Mexico's first titanium dioxide producer. There is every reason to suppose that domestic demand for sulphur will continue to increase.



Monsanto Mexicana S.A. General view of the 50 tons per day brimstone burning sulphuric acid plant commissioned in 1957 by Pan American Consulting Co. Inc.

Last year Mexican Frasch sulphur production used only about 60% of the industry's rated capacity. While the rising domestic demand for sulphur is certainly welcome to the Mexican Frasch producers at the present time of intense competition in the export market, it is evident that it is on their ability to sell abroad, that their future prosperity depends. The prosperity or otherwise of the Mexican Frasch sulphur producers in world markets is of great concern to the Mexican Government. Apart from the industry's rôle as a foreign exchange earner—it is at present the sixth largest—it contributes significantly to the tax revenue and makes a great impact on the social structure in the mining area not only as a sizeable employer but in bringing a high standard of living and education to a primitive part of the country. Demands for Nationalisation of the industry, which have been voiced from time to time, especially by some extremist labour leaders and which have given rise to a crop of rumours, are at present groundless. There is little doubt that under conditions of severe adversity the individual companies would have to give serious consideration to integrating at least some aspects of their activities, and only then, if the industry were to founder for lack of profitability, would the threat of Nationalisation assume greater imminence. Despite the under-employment of installed Frasch sulphur capacity, production is soundly based and still profitable especially in the case of Pan American Sulphur Company. That the industry has almost succeeded in maintaining its volume of exports is a sign of strength. With the continued business expansion in the U.S.A. and an entrance made in the Asian and South American markets, there appears to be no reason why the optimism—particularly of the Pan American Sulphur Company—should not be justified. Nevertheless the most rapid expansionary phase appears to be over.

United Kingdom Sulphur

Consumption of sulphur in all forms in the United Kingdom in 1959 rose to a total of 1,152,000 tons, an increase of 70,000 tons (6½%) over the previous year and a small increase of 10,000 tons (1%) over 1957 the previous record total in 1957.

Table I shows the relation between the index of industrial production and that of Consumption of Sulphur in all forms. It should be noted that although the index of industrial production in 1959 showed an advance of 5% over 1957, that for sulphur consumption only registered a rise of 1%. The recession in sulphur usage in 1958 (notably in textiles and to a lesser extent steel and fertilizers) is clearly shown, and following the boom conditions which become evident in the second quarter 1959, sulphur consumption rose accordingly

TABLE I.

	Index of Industrial Production	*Index of Consumption of Sulphur in All Forms*
1954 ..	100	100
1955 ..	105	102
1956 ..	107	106
1957 ..	107	109
1958 ..	106	103
1959 ..	112	110

to a record level. Demand from all sectors of the sulphur/sulphuric acid consuming industries remained firm, further accentuated by a strong consumers' market and a substantial volume of investment in many sectors of the economy.

Indigenous production of sulphur in all forms rose to a record figure of 583,000 tons, an increase of 6,000 tons over the previous year. Anhydrite consumed for sulphuric acid and ammonium sulphate manufacture accounted for 60% of the total domestic production. Increased supplies of elemental sulphur were obtained from refining imported crude oils while the recovery in the zinc industry led to the smelting of a greater tonnage of zinc concentrates resulting in the recovery of a greater volume of sulphuric acid. The production of spent oxide in the United Kingdom has been maintained but this material is becoming an embarrassment to the Gas Boards, not only because of a reduction in use in the United Kingdom but also because of the complete

TABLE II.

Production of Sulphur in all Forms

Thousand tons Sulphur Content

	1958	1959
Anhydrite ..	352	352
Zinc Smelter Gas	46	57
Spent Oxide ..	116	107
Hydrogen Sulphide	12	12
Recovered Sulphur	50	55
Pyrites ..	1	1
Total ..	577	583

disappearance of exports to the continent of Europe. Imports of sulphur into the United Kingdom advanced by 30,000 tons to 490,000 tons at a cost of nearly £5.2 million. The unit cost of imports declined for the fourth consecutive year and in 1959 was £10 12s. per ton of sulphur.

Production and Imports

Anhydrite. Production of this material was maintained at similar levels as in the previous year, totalling about 1.7 million tons. Two notable milestones were reached during the year. The first took place in Cumberland at the Long Meg Mine where the first Millionth Ton was mined during May. Mined by the Long Meg Plaster & Mineral Co. Ltd.—one of the Gotham Group of Companies—the anhydrite is sent by rail to the Widnes sulphuric acid plant of the United Sulphuric Acid Corporation; approximately one-quarter of a million tons are consigned annually. The largest mine in the United Kingdom is that of Imperial Chemical Industries situated at Billingham, and by early 1959 over 20 million tons had been produced from this one mine. Up to 1947 the mine had been operated on a principle similar to that employed in coal mining. At that date, however, the mine was reorganised on the "trackless mining" principle and a large number of diesel vehicles

were introduced. Productivity was so increased that only eighty miners working on each of the three producing shifts per day can mine some 23,000 tons of anhydrite per week. Production at this mine in 1958 was estimated to have been just under 1.2 million tons; of the total, nearly 300,000 tons were used by the company in the manufacture of sulphuric acid and cement, the remainder in the direct manufacture of ammonium sulphate. No change in output is reported at Solway Chemical Company's mine at St. Bees, Whitehaven, although plant is being installed to increase production by 50% in order to meet the increased requirements of Solway Chemicals Ltd. when the third kiln is installed.

Recovered Sulphur. Recovery capacity at the beginning of 1959 totalled 90,000 tons brimstone and no new capacity is projected for 1960. Output is estimated to have totalled about 55,000 tons. Production at the Fawley refinery of Esso Petroleum Company Ltd. increased only a little after the second sulphur plant was taken into operation as first a fire at the refinery and later in the year, a plant mishap, affected operation. One of the most notable features of this sector of the industry has been the transportation of molten sulphur; the specialised techniques employed by Messrs. F. W. Berk & Co. Ltd. developed in conjunction with deliveries from the Fawley refinery, have led to the company securing contracts at other oil refineries for the purchase of all surplus molten sulphur.

Night view of the hydrodesulphurizer at the Stanlow refinery. Hydrogen sulphide from this unit may be used either for sulphuric acid or brimstone production by the Shell Chemical Co.

Smelter Gas. The production of sulphuric acid from the roasting of zinc concentrates increased by 24% during the year in response to an improved demand for zinc in domestic and world markets. Actual acid production at the Avonmouth and Swansea smelters totalled 161,000 tons, equivalent to 57,000 tons sulphur content, the same amount as that produced in 1957.

Brimstone Imports. Greater demand for brimstone from acid manufacturers caused a rise in the level of imports to 375,370 tons, an increase of 47,000 tons (15%) over the previous year. With the exception of the United States, brimstone imports into the United Kingdom are the largest in the world and the market is the focus of the principal exporting countries. As anticipated, the average value per ton of brimstone continued to decline and was £10 16s. compared with £11 7s. per ton in the previous year.

TABLE III

	1958		1959	
	Tonnage	*Average Values*	*Tonnage*	*Average Values*
France ..	12,588	£11 9s.	48,739	£11 1s.
U.S.A. ..	253,800	£11 9s.	261,279	£10 15s.
Mexico ..	61,774	£10 17s.	65,332	£10 8s.
Belgium ..	111	£39 16s.	20	£27 16s.
Total	328,273	£11 9s.	375,370	£10 16s.

Brimstone imports from the United States in 1959 slightly increased in volume but the share of total imports of 70% was less than in 1958; the same applied to Mexican imports which accounted for 17½%. This change in pattern was occasioned by significant volumes of sulphur imported from France (12½%). Table III sets out the tonnage of brimstone imports and average values per ton for 1958 and 1959.

Sulphur Filter Cake. Imports of sulphur filter cake rose to 16,617 tons in 1959 at an average value of £6 11s. per ton. The volume of material obtained from the United States showed no appreciable change, while France became a supplier for the first time; totalling 1,904 tons, the average price was only £4 10s. The drastic fall in price compared in 1958 is occasioned partly by limited disposal facilities for this material and also by the flexibility of operations by the sole user in the United Kingdom—Nitrogen Fertilizers Ltd., at Flixborough—whose sulphur needs can be met in the form of filter cake, spent oxide or pyrites; as indicated above spent oxide is at present exceptionally cheap.

Pyrites Imports. As the result of a further contraction in pyrites usage imports declined to 213,772 tons. The volume of pyrites from Cyprus remained constant but in view of the reduction in total imports, their share increased from 55% in 1958 to 64% in 1959. Imports from Spain only accounted for 10% of pyrites imports in 1959 compared with 20% in the previous year. Pyrites concentrates from Sweden and Canada gained ground while there was one small shipment of pyrites concentrate from Avoca in Eire.

TABLE IV.

	1958		1959	
	Tons	*Average Value*	*Tons*	*Average Value*
Cyprus ..	135,100	£5 13s.	136,864	£4 18s.
Eire ..	877	£7 5s.	1,257	£4 2s.
Sweden ..	16,371	£4 17s.	26,457	£4 12s.
Portugal	10,306	£4 13s.	—	—
Spain ..	49,360	£5 9s.	22,710	£5 4s.
Canada ..	33,120	£4 17s.	26,484	£5 0s.
Total ..	245,134	£5 8s.	213,772	£4 18s.

Low freight rates prevailed for most of 1959 and contributed to low landed prices. 1959 is the fourth consecutive year in which the average value per ton of pyrites has declined.

Consumption

Increased consumption of sulphurous raw materials was recorded in both sulphuric acid and "non-acid" sectors of the industry, while the amount of anhydrite consumed in the direct manufacture of ammonium sulphate fell fractionally. Total consumption of sulphur in all forms is estimated at 1,152,000 tons, of which 856,000 tons was directed to sulphuric acid manufacture, 102,000 tons for "regular" uses and 194,000 tons sulphur contained in anhydrite for ammonium sulphate manufacture.

Acid Sector. The record level of sulphuric acid production during 1959 has occasioned a significant expansion in the consumption of elemental sulphur. This was anticipated following the emergence of a new pattern of sulphur consumption in 1957 when anhydrite acid plants were fully operational and many plants based on pyrites and spent oxide usage were being closed or re-equipped with brimstone burners.

Although ample low cost supplies of brimstone have been the main factor determining the new sulphur consumption pattern in the United Kingdom, the principle of flexibility has not by any means been abandoned; but pyrites, and to a lesser extent spent oxide, use has been confined to the most economic units.

The increase in brimstone consumption of 61,000 tons to 383,600 tons (+19%) is attributable almost entirely to the activities of Messrs. Courtaulds Ltd., Fisons Ltd., British Titan Products Co. Ltd. and Laporte

Titanium Ltd. The disappearance of the recession in man-made fibres towards the end of 1958 has led to an increased use of elemental sulphur at Trafford Park, while Fisons Ltd. continue expanding the use of acid for superphosphate and phosphoric acid production at their Immingham plant. The manufacture of titanium dioxide expanded by almost 20% in 1959 and over one-half of all the acid requirements of this sector are met from brimstone. British Titan Products Co. Ltd. is the largest manufacturer of sulphuric acid in the United Kingdom and at Grimsby has installed capacity of 800 tons per day (100% H_2SO_4), all of which is captively consumed for titanium dioxide manufacture. The commissioning of the new 250 tons per day brimstone burning contact acid plant at Billingham substantially increases the company's brimstone use and will also make their titanium dioxide plant at that location independent of "bought in" acid.

Anhydrite consumption for acid manufacture totalling 748,000 tons, has only fractionally declined compared with 1958 and acid capacity has been fully utilized since 1957. The plants at Whitehaven (Solway Chemicals) and Billingham (Imperial Chemical Industries Ltd.) have operated satisfactorily, while at Widnes, the plant of United Sulphuric Acid Corporation Ltd. is reported to have been taken out of commission for a short while in the middle of the year in order to modify it. Capacity here has been increased by 15% but so far this does not appear to have been utilized.

Spent oxide use continues to recede and in 1959 consumption of this material totalled 221,800 tons, a decline of 8½% compared with 1958. In spite of the low cost per unit of sulphur contained in spent oxide, adverse factors, like cheap and ample supplies of brimstone and sulphuric acid and the advantages in terms of labour and overheads of operating

TABLE V.

CONSUMPTION OF SULPHUROUS RAW MATERIALS

	1959	1958	% Change	1959 4th Quarter	1958 4th Quarter	% Change
Elemental Sulphur :						
Total Acid Sulphur	383,600	322,400	+19	108,100	89,900	+20¼
Imported	327,800	277,600	+18	93,600	76,300	+22¼
Recovered H_2S and filter cake ..	55,800	44,800	+24½	14,500	13,600	+6½
Non-Acid	102,000	91,000	+12	26,000	23,000	+13
Total Elemental Sulphur	485,600	413,400	+17½	134,100	112,900	+18¾
Pyrites	319,300	327,700	— 2½	84,900	75,600	+12¼
Spent Oxide	221,800	242,700	— 8½	59,900	60,800	—1½
Anhydrite	748,000	749,000	—	188,300	200,600	—6¼
Zinc Concentrates	191,600	152,200	+26	49,800	42,200	+18

Amongst plants which are reported to have been converted from pyrites roasting to brimstone burning is that of the Associated Ethyl Co. Located at Ellesmere Port, the plant has a daily capacity of 35 tons and the conversion was engineered by Simon-Carves Ltd.

The modest use of domestic recovered brimstone and H_2S in the acid industry—estimated at 40,000 tons—was nearly 10,000 tons greater than in the previous year but as it only represents 10% of brimstone usage, does not affect the import pattern.

large plants are now affecting this sector of the industry. The temporary decline in the early autumn of by-product ammonium sulphate manufacture—a traditional outlet for spent oxide derived sulphuric acid—also reduced the size of the market.

Zinc concentrates consumption responded to brighter conditions in 1959 in the zinc market and their use rose by 21% to 191,600 tons. The recovery of 161,100 tons of sulphuric acid represents the equivalent of 57,000 tons sulphur all produced at the zinc smelters

operated by the National Smelting Corporation at Avonmouth and Swansea.

Pyrites usage in the United Kingdom has declined each year since 1954 and now totals 319,000 tons. It is believed that consumption will remain stable at about this level as the existing capacity is nearly all of modern design and is based on the use of pyrites concentrates.

"Non-Acid" Sulphur. In response to the improvements in the domestic economy during 1959, together with the revival in the man-made fibres industry, consumption of brimstone for non-acid uses was estimated to have risen to 102,000 tons. The use pattern is as follows :—

TABLE VI
(000 tons)

	1959	1958
Carbon disulphide ..	52	45
SO_2 and Sulphites ..	15	14
Rubber ..	10	9
Agriculture ..	5	5
Ultramarine ..	4	4
Wood Pulp ..	3	3
Other ..	13	11
Total ..	102	91

The revival of viscose production substantially increased Messrs. Courtauld's requirements of brimstone for use in the manufacture of carbon disulphide at their works at Greenfields, N. Wales, Carrickfergus, N. Ireland, and Trafford Park, Manchester. Although sulphur usage for carbon disulphide increased in 1959 over the previous year, consumption was about 15% lower than that recorded in the years 1953-57, although the difference between actual production of viscose in 1959 is similar to that produced in these earlier years. The reduction in net sulphur use is mainly on account of carbon disulphide recovery at the new plant at Greenfields, N. Wales, which started operating in the middle of 1959.

Of the other producers of carbon disulphide whose combined level of activities is only about one-quarter of U.K. output, Hardman & Holden Ltd. and West Cumberland By-Products Ltd., appear to have expanded their brimstone requirements. Of the other non-acid sulphur using industries, sulphur dioxide manufacture appears to be most active.

The high level of demand for "consumer goods" stimulated a wide range of industries consuming small volumes of brimstone. The level of brimstone demand from these industries—in particular for rubber, bleaching and pigments—rose to a level comparable to that achieved in 1957.

Sulphuric Acid Production*

Sulphuric acid production in 1959 rose to the record total of 2,428,504 tons (100% H_2SO_4), an increase of 187,000 tons, or 8¼% over the previous year. Output of contact plants rose impressively to a total of 2,022,831 tons and now accounts for 83½% of total production compared with 78½% in the previous year. The following table sets out the percentage of sulphuric acid produced from the various raw materials :—

TABLE VII

	1959 Acid Production 100% H_2SO_4	% age of total	1958 % age of total
Pyrites	418.8	17.2	19.0
Spent Oxide ..	293.1	12.1	14.2
Sulphur	1,114.1	45.9	
Imported	958.2	39.5	36.1
Recovered, H_2S and Filter Cake ..	155.9	6.4	5.5
Zinc concentrates ..	161.1	6.6	5.7
Anhydrite	441.4	18.2	19.5
Total (thousand tons)	2,428.5	100%	100%

Installed capacity of chamber and tower plants has further declined and in 1959 totalled 573,680 tons of which only 70.7% was utilized (77.6% in 1958). This is in contrast to contact plants of which installed capacity rose by 5¼% to just under 2.4 million tons and employment rose from 80.4% in 1958 to 84.3% in 1959.

Sulphuric Acid Consumption

Sulphuric acid consumption in 1959 totalled 2,455,776 tons (100% H_2SO_4), an increase of 8¼%—187,000 tons—compared with

* We are indebted to the National Sulphuric Acid Association for information placed at our disposal.

1958. Improved level of industrial activity in the United Kingdom was reflected in nearly all acid consuming industries. There was a notable expansion of acid use in the titanium dioxide industry—following the completion of new capacity at Grimsby, Stallingborough and Billingham—while the recovery in man-made fibres stimulated acid needs for viscose manufacture in addition to acid usage in the manufacture of dyestuffs. Consumption in the fertilizer industry increased fractionally but within this total consumption in the phosphate sector rose 5½%—mostly for phosporic acid for triple superphosphate and complex fertilizers—whereas its use for ammonium sulphate declined (7½%).

The modest growth of acid use in the detergent sector does not reflect the strong boost to acid demand for liquid detergents, which are recorded under another heading.

Consumption in the principal consuming groups is as follows :—

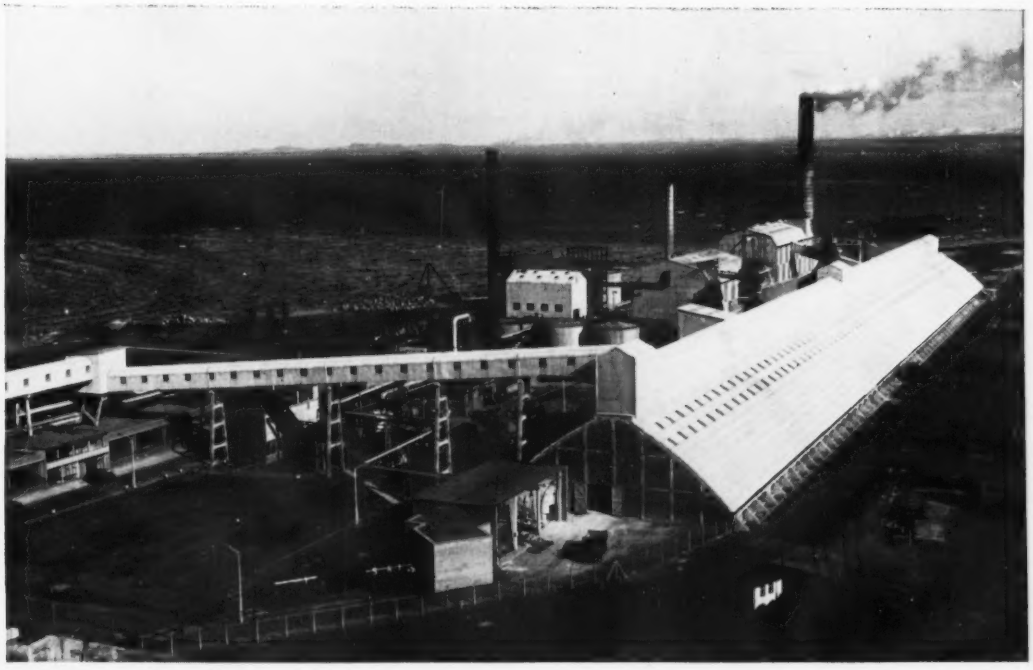
TABLE VIII

	1959	%	1958	%
	Thousand Tons			
Fertilizers ..	840.5	34.3	832.4	36.7
Superphosphates	568.4	23.2	538.1	23.7
Ammonium Sulphate ..	272.1	11.1	294.3	13.0
Titanium Dioxide	401.6	16.4	322.1	14.2
Chemicals ..	271.2	11.0	249.6	11.0
Rayon and Transparent paper ..	259.5	10.6	240.2	10.6
Metallurgy ..	125.6	5.1	117.5	5.2
Soap, Glycerine and Detergents ..	118.3	4.8	117.9	5.2
Oil Refineries ..	64.8	2.6	55.5	2.5
Dyes ..	98.6	4.0	75.5	3.3
Plastics ..	49.0	2.0	40.9	1.8
Miscellaneous ..	226.7	9.2	216.4	8.5
Total ..	2,455.8	100.0	2,268.2	100.0

The major changes in acid consumption compared with 1958 were as follows :—

TABLE IX.

	Tons	Change %
Titanium Dioxide ..	79,500	+24.7
Superphosphates	30,300	+ 5.7
Dyestuffs and Intermediates	23,100	+30.8
Rayon and Transparent Paper	19,400	+ 8.0
Sulphate of Ammonia ..	22,200	— 7.5



General view of fertilizer plant at Leith of Scottish Agricultural Industries Ltd. The plant comprises sulphuric and phosphoric acid units and is capable of making a wide range of fertilizers.

Outlook

The significant increase that occurred in United Kingdom industrial activity in 1959 has been attributable to the high level of consumer demand. In the years 1955-1958 there had been a stagnation in the economy and this was all the more serious because investment had continued throughout the period. The increased demand for consumer goods in 1959 has considerably raised utilization of industrial capacity and the trend is likely to continue into 1960. The pattern of sulphur consumption shows similar characteristics although instead of stagnation in the years 1955-57, there was an annual growth of 3½%, due principally to the development of certain industries, notably titanium dioxide; the marked fall in 1958 was attributable to the decline in man-made fibres as well as the general industrial recession.

The tenor of the industrial activity and the planned developments by the principal acid consuming industries indicate that consumption of sulphur may well rise to the record total of 1.2 million tons in 1960. Consumption of sulphur contained in anhydrite is expected to advance, possibly as much as 40,000 tons, mainly as the result of expansion at the Whitehaven plant of Solway Chemicals where acid capacity is to rise by 50% and full utilization of the plant operated by United Sulphuric Acid Corporation at Widnes. No major changes are expected in the level of use of pyrites and spent oxide or of by-product acid manufacture from zinc smelter gases. The use of copperas and waste pickle liquor from titanium oxide and steel works effluents is, however, a new source of by-product sulphur which in 1960 should contribute at least 12,000 tons sulphur in the form of sulphuric acid. The principal expansion is foreseen in the use of brimstone for sulphuric acid production, especially that of imported origin, as domestic sulphur production will rise only slightly, and total consumption—including filter cake, but excluding hydrogen sulphide —will, for the first time, exceed one-half million tons and probably rise to about 530,000 tons. A technical development of particular interest to pyrites users, and which might affect the future pattern of sulphur use is a modification to flash roasters developed by Fertilizers and Chemicals Limited, Haifa, which offers a means of using alternatively pyrites concentrates and brimstone with equipment that can be switched in little more than one hour.

The principal developments foreseen in the sulphuric acid consuming sectors are the expansion of titanium dioxide capacity at Billingham and Stallingborough, that taking place at Fisons triple superphosphate plant at Immingham and the continued strength of the viscose and transparent paper industries. The latter effecting both acid and non-acid sectors.

British Cellophane Ltd., a subsidiary of Courtaulds, are expanding their plant at Barrow by one-third so that when in full operation, the plant could consume about 10,000 tons of sulphuric acid and 3,000 tons carbon disulphide. Raw materials are supplied by Courtaulds from Trafford Park. Capacity at the plants of British Rayophane Ltd., at Wigton, Cumberland, and Transparent Paper Ltd., at Bury, Lancs., now fully utilized may also be expanded. In view of the growth in transparent paper needs in the United Kingdom, principally in the packaging field, British Enka have decided to instal plant to produce cellulose wrapping at their Aintree works and are to extend the capacity of their viscose plant accordingly. It is reported that the Dutch A.K.U. Group will render technical assistance. The high level of car production will also stimulate demand for brimstone used in the vulcanisation of rubber tyres as well as for the high tenacity yarn used for tyres.

The overall picture is one of strength and it is expected that sulphuric acid production and consumption in 1960 will total about 2.6 million tons. Of the anticipated consumption of 1.2 million tons sulphur in all forms, over 52% should be met from indigenous resources and the additional needs by greater imports of which French recovered sulphur is likely to secure a greater share.

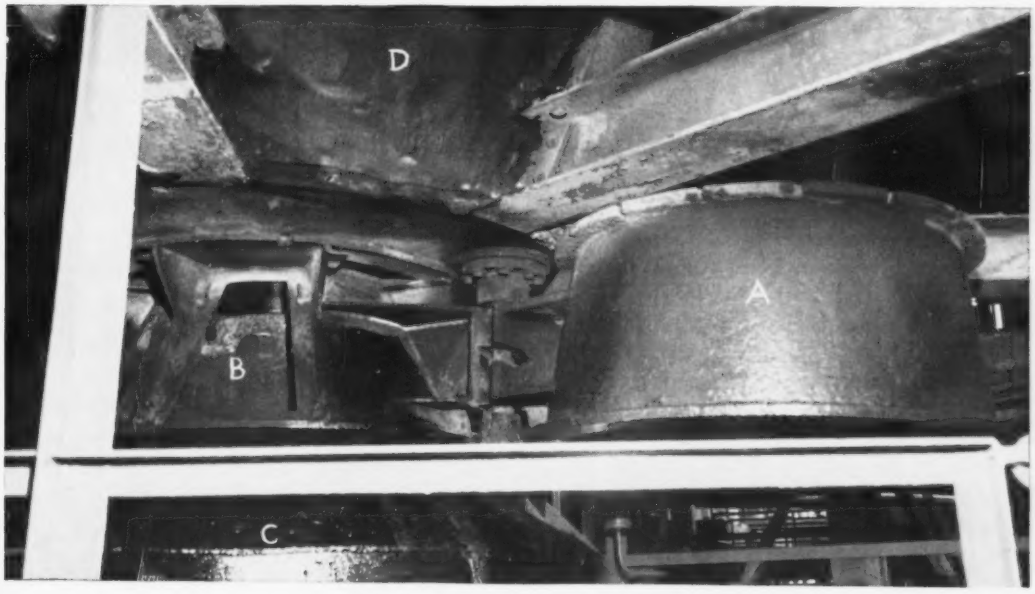
Pyrites Flash Roasters Adapted For Brimstone Burning

Fertilizers & Chemicals Ltd., Haifa, Israel, installed a pyrites-burning sulphuric acid plant with a daily capacity of 240 tonnes (100% H_2SO_4) in 1951 when the world supplies of brimstone were very limited and their distribution internationally controlled. As brimstone again became freely available, Fertilizers & Chemicals, like many other acid producers, found that a total or partial changeover to brimstone would be economic, and the existing Nichols-Freeman flash roasters had to be modified accordingly.

A decision was therefore taken to instal the necessary ancillary equipment comprising a melting pit, molten sulphur pumps—of the Company's own design and manufacture—lines, and sulphur guns. In converting the pyrites roasters to sulphur burning, particular emphasis was laid on developing an installation capable of changing from one raw material to the other in the shortest possible time. The photograph shows how this was achieved.

The slightly conical section on the right, which can be swung aside, connects the bottom of the roaster with the calcine hoppers. It was decided to instal the brimstone burner on a second swing bell, fastened to the shaft of the original bell, this is shown in operation in the photograph, where the sulphur cone can be seen in centre-left. Change-over from sulphur to pyrites, or vice versa, requires no more than disconnection of sulphur piping, and swinging the alternative bell into place—the whole operation requiring only about one hour. With three flash roasters available it is of course also possible to operate simultaneously with both raw materials at will.

This unit was installed 3½ years ago and continues performing satisfactorily.



View of the conversion of the Nichols-Freeman Flash Roasters installed at the plant of Fertilizers & Chemicals Ltd., Haifa. A, Original swing bell; B, Second swing bell with sulphur burner; C, Calcine hopper; D, Bottom cone of roaster.

Current Events

CYPRUS

1959—First 10 Months Exports

The two influences to which the Cypriot pyrites industry is subject may be clearly seen from the figures of exports of copper and sulphur materials in the first ten months of 1959. On the one hand the average price

EXPORTS

	Jan.-Oct., 1958	*Jan.-Oct., 1959*	Change
Cement Copper :			
Tons	2,442	3,046	+25%
Average price ..	£100 2s.	£130 0s.	+£29 18s.
Copper Concentrates :			
Tons	107,571	103,839	—3%
Average price ..	£24 3s.	£31 7s.	+£7 4s.
Cupreous Pyrites :			
Tons	192,630	267,209	+39%
Average price ..	£6 5s.	£6 10s.	+£0 5s.
Iron Pyrites :			
Tons	713,632	608,194	—15%
Average price ..	£4 1s.	£3 1s.	—£1 0s.
TOTAL VALUES ..	£6,924,462	£7,251,673	+5%

of copper materials was for once considerably higher than the corresponding period in the previous year, largely on account of the copper strikes in the U.S.A. and in Chile; and both the average price and tonnage of cupreous pyrites exports showed an increase. On the other hand the world price of sulphur materials was again lower; and both the average price and tonnage of iron pyrites exports fell as compared with those of the first ten months of 1958.

While the 5% increase in the total value of copper and sulphur materials exported must be a welcome change from the downward trend experienced by the Cypriot pyrites industry for the past five years, little comfort will be derived from the consideration that the very slight world copper shortage is unlikely to last for nearly so long as the world sulphur glut.

CANADA

Integrated Sulphuric Acid/Leaching Circuit

The New Manitoba Mining and Smelting Company has planned a completely integrated operation for exploiting its copper and nickel ore deposit in the Bird River area, 100 miles north-east of Winnipeg, and has provided yet another reminder that an increase in the use of sulphuric acid need not be reflected in a greater demand for brimstone on account of the greater importance of by-product sulphuric acid production.

The mine is to be reopened early in 1960. A 1,000-ton mill is already on the site and the first concentrates are expected to be ready in April. By this time a 50 tons per day sulphuric acid plant is scheduled for completion by the Chemical Construction Corporation of New York, who have already started work on it. This will incorporate heat recovery and will be a contact unit having a four-pass converter using a vanadium catalyst. The concentrates will be roasted at this plant and the resulting sulphuric acid will be used for leaching the calcines for the recovery of their nickel and copper content. The leached iron calcines are to be smelted in an Electrokemisk furnace, which is to be built nearby, at an annual rate of 42,000 tons for the production of 21,000 tons of pig iron.

The leaching plant is to be built by New Manitoba, but the sulphuric acid plant is to be the responsibility of the Borden Chemical Company, which has a 25% holding in the former firm. The Westcan Iron Corporation will build the pig iron plant.

U.S.A.

Closure of Bay Ste. Elaine Dome

Freeport Sulphur Company's Bay Ste. Elaine Frasch mine was closed late in December as a result of exhaustion of reserves. The mine, located in the marshlands on the edge of the Gulf of Mexico 20 miles south of Houma, Louisiana, began operations in November, 1952, and since that date has produced 1,113,000 tons. No sulphur in commercially recoverable quantity was left in the deposit.

Bay Ste. Elaine was the first of four mines developed by Freeport in its efforts to alleviate the sulphur shortage of the early 1950's. Although not a major property, the mine produced important quantities of sulphur at a critical period and, equally important, it served as a full-scale testing operation for the first use of sea water in the Frasch mining method. The success of the sea-water process made it possible for the company to develop the Grand Isle offshore deposit.

Another unique feature of Bay Ste. Elaine was the mining plant which was built in its entirety on a large steel barge, floated to the site and partially sunk on a prepared bed. The relatively small size of the deposit did not justify a permanent installation, necessarily expensive because of the remote, marshland location.

Bay Ste. Elaine was also the proving ground for directional drilling of sulphur wells —a technique which will be used at Grand Isle. By deflecting the drill, wells are deviated to reach sulphur over a wide area. Thus at Grand Isle as many as 108 wells will be driven from a single drilling platform location, with a deviation of as much as 1,250 feet from the surface location.

With the closing of Bay Ste. Elaine, the mining plant barge will be refloated and moved a few miles south to a new deposit called Lake Pelto where it will be maintained on a stand-by basis. The development of the Lake Pelto deposit has been postponed for the present because of the adequate new productive capacity which Grand Isle will furnish when it comes on stream this spring.

Sulphuric Acid for Caprolactam

The Du Pont Company's engineering department has undertaken the construction of a new sulphuric acid plant, which is expected to come on stream towards the end of 1960. It will be situated at the company's works on the Galveston-Houston ship canal opposite Baytown in Texas ; and it is to supply acid for Du Pont's caprolactam plant now being built at Beaumont, as well as providing an additional source of supply for the petroleum and chemical industries of the Gulf Coast area ; and the acid will be transported by barge, rail or road.

The sulphuric acid plant is to be a contact unit having a vanadium catalyst and it has been designed to operate on a mixed feed consisting of brimstone and sludge acid. It will make all standard grades of sulphuric acid, including oleum. Its capacity has not been disclosed, but the company has announced that it will be one of its largest plants.

WEST GERMANY

Largest Carbon Disulphide Plant

In 1958 West Germany was surpassed as a producer of rayon and acetate only by the U.S.A. and Japan and in that year her output of these materials was 475.4 million pounds. With the strong upward trend that has since carried the artificial fibres industry to a record level of output an expansion in West Germany's carbon disulphide capacity was to be expected. It has now been announced that a company which is to make carbon disulphide has been formed by Glanzstoff Courtaulds of Cologne, manufacturers of viscose rayon, and Dr. Jacob Chemische Fabrik G.m.b.H. of Bad Kreuznach, the country's largest carbon disulphide producer. The new company, *Carbosuf Chemische Werke G.m.b.H.* of

Cologne, has a nominal capital of DM 4,500,000, or £375,000. It will build and operate at the Glanzstoff suburb of Cologne a plant for producing 52,000 tonnes of carbon disulphide a year.

The plant is to be based on the increasingly popular methane process, which was originally developed by the Pure Oil Company and of which the licensor is now the Food Machinery and Chemical Corporation of New York. Purified methane at a pressure of about 60 pounds per square inch and liquid sulphur in approximately stoichiometric proportions pass through a furnace in which the sulphur is vapourised and mixes with the methane at a temperature of about 1,200°F. The vapour mixture then enters the reactor in which carbon disulphide and hydrogen sulphide are formed over a silica gel catalyst. The rate of conversion is approximately 90-95%. From the reactor the vapour stream containing carbon disulphide, hydrogen sulphide, and some unreacted sulphur passes to a condenser in which most of the unreacted sulphur is separated. This is small in quantity and may contain accumulated tars but can be recycled to the melting pit. After leaving the condenser the temperature of the gas stream has fallen to about 100°F but a little unreacted sulphur still remains. It then passes into a carbon disulphide scrubber. After the partial condensation of carbon disulphide from the scrubber effluent, the gas stream flows to an absorption tower in which the remaining carbon disulphide is absorbed by a light oil solvent. The gases from the absorber contain 90-95% hydrogen sulphide from which the sulphur is subsequently recovered conventionally in a Claus kiln and is then recycled. The oil from the absorber goes to a column in which steam stripping separates the carbon disulphide, which then passes into a distillation column where the remaining traces of hydrogen sulphide are removed. The bottoms from the column are pumped to a final distillation stage where the heavy ends drop out. The overhead is condensed and removal of any traces of hydrogen sulphide in it is achieved by caustic soda washing.

By the methane process the yield of carbon disulphide from sulphur is now almost entirely determined by the efficiency of the sulphur recovery unit, although a factor of minor importance is the recycling of elemental sulphur from the condenser through which pass the exit gases from the reactor. For the type of Claus kiln developed by Courtaulds in Great Britain a 90-95% rate of sulphur recovery is claimed. From this it is estimated that the plant will annually require the equivalent of about 48,000 tonnes of sulphur, giving an overall conversion similar to that of the most modern electric process plants and better than that of plants based on the traditional retort process. Raw materials will come in part from local oil refineries and the co-ordination of the plant with the existing sulphuric acid and synthetic fibre units of Glanzstoff Courtaulds will also enable use to be made of the waste gases from them. Construction of the plant is expected to take about two years. When completed it will increase West Germany's present carbon disulphide capacity by more than 50%.

SWITZERLAND

Carbon Disulphide Plant for U.S.S.R.

Ing. A. Maurer S.A. of Berne is currently building an electric process carbon disulphide plant for Technopromimport to be installed at Kalinin near Moscow. It will have a daily capacity of 5 tonnes of high purity carbon disulphide. A feature claimed for Ing. A. Maurer's plants is that the sulphur content of their carbon disulphide does not exceed 1-2 milligrammes per litre, and this makes it attractive for making viscose. A similar plant is under construction for Travancore Rayons Ltd. and is to be installed at Rayonpuram in India.

The furnaces of Ing. A. Maurer's plants are fitted with water-cooled steel electrodes, the heads of which are protected by a coating of "Soederberg" paste, a special graphite material. The customary form of carbon used is charcoal with a grain of 15-60 mm. containing approximately 15% of volatile matter, which is reduced to about 1% in the calcinator.* The company is now experimenting with the use of carbon in the form of oil refinery coke.

YUGOSLAVIA

World's Largest Superphosphate Plant

In the past eight years there have been repeated rumours of a plan to build an enormous superphosphate works at Prahovo. These rumours are now at last justified, for the construction work on such a plant has in fact been half completed by the Moritz Chemical Engineering Company. Sulphuric acid will come from a 230,000 tons per annum plant which is being built in connection with the large copper smelter 53 miles away at Bor to treat the ore from the extensive deposits both at Bor and at Majdanpek. It is reported that the contract for the sulphuric acid plant has been placed with Hugo Peterson of Wiesbaden. The Prahovo superphosphate plant is due on stream in 1961 and its capacity will be 575,000 tons annually, some of which is to be in powdered and some in granulated form. At a later stage it is intended that some of the output shall be used for making compound fertilizers.

By an agreement signed with the U.S.S.R. in 1956 Soviet credits were to be granted for the purchase of capital equipment for agriculture from the U.S.S.R. Under this scheme it was planned to build both the Prahovo works and another superphosphate plant to be situated at Kosovska-Mitrovica. Here 120,000 tons of sulphuric acid were to be manufactured annually from the Trepca mines' pyrites and the output of superphosphate was to be 250,000 tons. The plan was shelved in 1958 after the withdrawal of Soviet credits. However the Moritz Chemical Engineering Company has now received the order for the design and engineering of a superphosphate plant for Kosovska-Mitrovica, despite Japanese competition. The plant's capacity will now be in the region of 290,000 tons of superphosphate annually. While it is not known for certain when it is to come on stream, this is expected to be towards the end of 1962.

Current production of sulphuric acid in Yugoslavia is estimated at about 140,000 tons. When the Bor and Kosovska-Mitrovica sulphuric acid plants are in operation sulphuric acid capacity will be increased by about three and a half times to approximately 490,000 tons a year. Yugoslavian superphosphate output now stands at only about 130,000 tons, all of which originates from the Sabac and Subotika plants of the Zorka chemical combine, where capacity was considerably expanded in 1959. When the Prahovo and Kosovska-Mitrovica plants are on stream, Yugoslavian superphosphate capacity will be increased by more than sevenfold to approximately one million tons. However it is the official policy that Yugoslavia should become self-supporting in phosphatic fertilizers by 1965, and the country's requirements have been estimated at 1.2 million tons. Going by this figure it appears that the completion of Prahovo and Kosovska-Mitrovica alone will not achieve this end—especially as superphosphate plants rarely operate at maximum capacity—so that even more plant may be installed.

JAPAN

Sulphuric Acid. Jan.-June, 1959.

In the first six months of 1958 the Japanese economy was still in the depths of the recession from which it emerged towards the end of that year. In the first six months of 1959 the recovery was very much in evidence. Every sulphuric acid consuming sector recorded an increase in its intake over

* For further details see the Special Issue for 1959.

that for the corresponding period of the previous year. Quantitatively the most important increases were those for nitrogenous and phosphatic fertilizers followed in turn by those for artificial and synthetic fibres, and inorganic chemicals. The greatest relative increases were shown by the sulphuric acid consumption for dyestuffs and intermediates, followed by that for the iron and steel industries.

TABLE 1
SULPHURIC ACID CONSUMPTION

000 tonnes	*Jan.-June 1959*	*Change 000 tonnes*	*Change %*
Nitrogenous fertilizers	990	+ 92	+10¼
Phosphatic fertilizers	482	+ 60	+ 7
	1,472	+152	+8¾
Artificial and synthetic fibres ..	217	+ 26	+13½
Inorganic chemicals	122	+ 12	+10
Organic chemicals ..	36	+ 2	+ 5¾
Iron and steel ..	53	+ 11	+26
Petroleum ..	35	+ 6	+20½
Dyestuff and intermediates ..	21	+ 5	+31¼
Miscellaneous ..	168	+ 33	+24½
	2,124	+247	+13

Under the stimulus of the rise in demand sulphuric acid production was 11¾% higher than in the corresponding period of the previous year. Both quantitatively and proportionally the output from contact plants rose more than that from chamber plants, which in the first half of 1959 accounted for only 33% of total Japanese production.

TABLE 2
Sulphuric Acid Production
Jan.-June, 1959

000 tonnes	*Sulphur ores*	*Copper ores*	*Zinc ores*	*Total*
Chamber ..	621	56	23	698
Contact ..	1,124	165	109	1,398
Total	1,745	221	132	2,098
Tons Change				
Chamber ..	+ 17	+13	+ 4	+ 34
Contact ..	+149	+26	+11	+186
Total ..	166	39	15	220
% change				
Chamber ..	+ 2¾	+30¼	+24	+ 4¾
Contact ..	+ 15¼	+18¾	+11	+ 16
Total ..	10½	24	12¾	11¾

Most sulphuric acid in Japan is made from iron pyrites, pyrrhotite, and sulphur ore. The fall in the consumption of the last two materials was more than offset by the rise in the consumption of iron pyrites. A greater percentage increase than that of sulphuric acid from sulphur ores, although quantitatively much smaller, was that of sulphuric acid from copper and zinc ores taken together—a consequence of the large expansion and modernisation programme which is still being carried out in the non-ferrous sector of the Japanese metallurgical industry. Smelter gas from roasting lead ore had not been used for sulphuric acid manufacture before the second half of 1958. Consumption of other raw materials, the most important of which is spent oxide, fell sharply.

TABLE 3
Sulphurous Raw Materials Consumption

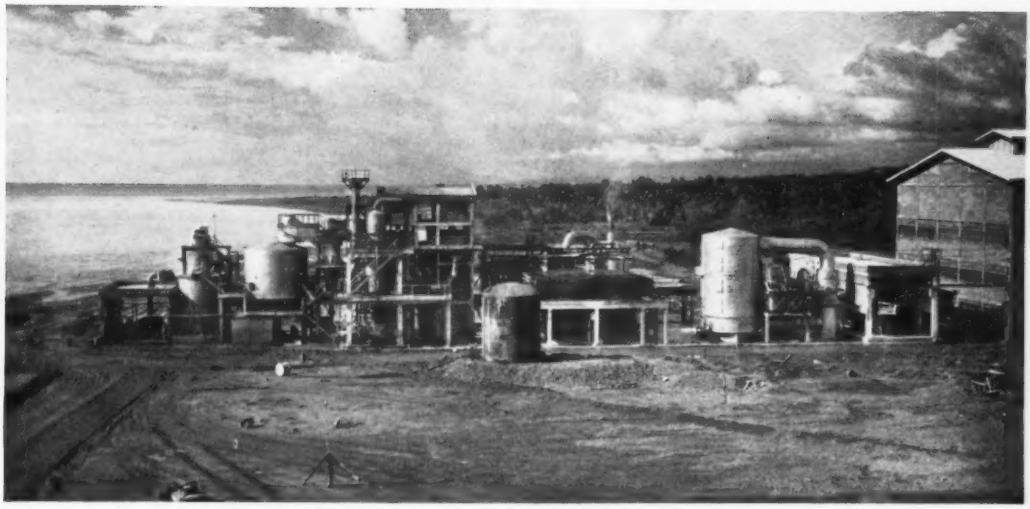
000 tonnes	*Jan.-June 1959*	*Change tonnes*	*Change %*
Iron pyrites ..	983	+128	+15
Pyrrhotite ..	113	— 11	— 9¾
Sulphur ore ..	317	— 26	— 8
	1,413	+ 91	+ 7
Zinc blende ..	128	+ 8	+ 6½
Copper concentrates and pyrites ..	128	+ 18	+16¼
Others ..	0.5	— 0.4	—44½
Lead ore ..	11.4	+ 11.4	New
	1,681	+129	+8¼

It appears likely that when the figures for the whole year are available the trend towards the greater use of smelter gas will still be in evidence. Additional plant is almost bound to be installed soon as it is estimated that in the first six months of 1959 the industry was operating at about 90% of its capacity.

PHILIPPINES

Maria Christina Fertilizer Plant

The Marinduque Iron Mines Agents Inc. have entered into negotiations with the *National Power Corporation* for the purchase of the Maria Christina fertilizer plant at Iligan City on Mindanao Island. This was the first important fertilizer works in the Philippines. Hydrogen is produced by the electrolysis of



General view of the sulphuric acid section of Atlas Fertilizer Corporation's fertilizer plant at Sangi, Cebu Island.

water ; nitrogen is isolated by the liquefaction of air ; and ammonia synthesis is conventional. There is a 120 tonnes per day Chemico sulphuric acid plant which was originally built to burn Texas bright sulphur but which has since been converted to the use of indigenous pyrite and volcanic ores in consequence of the expansion of the Philippines' mining industry, although stand-by sulphur burning equipment is still maintained. In 1957 tenders for a second ammonium sulphate unit of a similar capacity to the first were called for : but on account of exchange difficulties no order was placed ; and ammonium sulphate capacity remains at 50,000 tonnes annually. Marinduque Iron Mines are however considering the manufacture of urea.

The main object of the proposed deal is to incorporate the plant in an integrated operation for making copper and zinc products. Copper concentrates would come from the Marinduque Iron Mines' Sipalay mine, which currently produces about 3,000 tonnes (dry basis) of copper concentrates monthly with an assay of 24% copper, 30% iron, and 35% sulphur, and copper-zinc concentrates would come from the company's Bagacay mine, the monthly output of which is at present approximately 2,000 tonnes (dry basis) of copper-zinc bulk concentrates averaging 11% zinc, 17% copper, 29% iron, and 41% sulphur. The beneficiation of the pyrites tailings arising from the production of these concentrates has not been undertaken, as the demand for pyrites concentrates has been insufficient to warrant it. In the Philippines pyrites concentrates are used only by the Maria Christina plant and the Atlas Fertilizer Corporation's plant at Sangi on Cebu Island. Most of the requirements of the former and all of the requirements of the latter are met by the Atlas Consolidated Mining and Development Corporation.

POLAND

Trade Agreement

By an agreement between the Polish and Czechoslovakian Governments Poland is to supply Czechoslovakia between 1961 and 1964 with three sulphuric acid plants having a total capacity of 340,000 tonnes, and a large factory for synthetic phenol, while Czechoslovakia is to supply in exchange a large part of the equipment both for the planned oil refinery at Plock, which is to treat imported Russian crude, and for the great sulphur combine in the vale of Sandomiersk.

UNITED STATES

		PRODUCTION		STOCKS		EXPORTS	IMPORTS*
		Frasch	Recovered	Frasch	Recovered		
1956		6,427,229	480,980	3,936,450	119,446	1,651,597	203,044
1957		5,491,210	519,078	4,422,548	157,075	1,561,093	484,680
1958		4,644,812	619,594	4,442,066	177,271	1,567,072	582,659
1959	January	346,475	52,284	4,426,613	180,388	67,031	33,809
	February	317,696	54,295	4,375,557	177,902	123,269	53,447
	March	373,599	58,546	4,325,410	177,527	87,523	43,228
	April	390,757	48,929	4,248,242	169,605	137,371	56,404
	May	389,212	56,964	4,155,945	166,350	148,526	63,281
	June	346,887	58,679	4,078,807	162,911	125,337	91,659
	July	312,192	53,636	4,008,018	159,944	175,316	59,926
	August	368,561	54,169	3,875,792	156,342	178,010	49,928
	September	399,157	52,050	3,814,932	154,211	148,968	68,825
	October	483,086	49,950	3,899,128	145,185	125,474	29,091
	November	408,481	51,623	3,833,537	142,157	141,442	Not available

Official Bureau of Mines Data (long tons of 2,240lbs.) * Imports of sulphur from Mexico only.

SULPHUR EXPORTS

Long Tons

	July-Sept. 1959	*Jan.-Sept.* 1959	*Jan.-Sept.* 1958
Philippine Republic	123,347	1,123,123	1,123,123
Canada	109,797	205,242	210,751
N. Antilles ...	—	5,000	5,000
Columbia	206	314	—
Venezuela	9	2,291	1,486
Peru	2,200	3,509	2,000
Brazil	31,477	106,358	73,474
United Kingdom ...	79,255	200,055	210,541
Belgium	15,500	46,200	64,930
France	19,625	73,745	75,365
W. Germany ...	19,700	57,640	52,969*
Poland	10,000	23,240	2,500
Israel	6,250	11,250	7,500
India	27,877	84,137	85,625
Indonesia	700	5,400	4,600
New Zealand ...	22,350	50,919	26,754
Algeria	—	9,000	14,560
Union of S. Africa	8,287	43,387	50,000
Cuba	16,698	28,591	5,800
Uruguay	1,607	2,862	4,474
Argentine	20,248	29,997	23,071
Netherlands ...	20,300	27,300	10,400
Switzerland ...	9,550	25,900	40,905
Finland	5,900	10,600	25,099
Philippine Republic	26	874	907
Korean Republic ...	—	68	436
Australia	48,709	90,114	102,442

	July-Sept. 1959	*Jan.-Sept.* 1959	*Jan.-Sept.* 1958
Canary Islands ...	—	2,952	4,428
Guatemala ...	—	50	50
Paraguay	—	97	29
Austria	3,000	5,000	18,017
Yugoslavia ...	—	2,000	2,000
Syria	—	49	—
Tunisia	3,000	9,000	—
Lebanon	—	1,000	2,499
Bahrain	—	203	371
Saudi Arabia ...	521	1,382	90
Costa Rica ...	—	33	31
Iran	2,250	2,260	6,000
Pakistan	250	798	2,550
Denmark	—	1,000	—
Sweden	7,625	9,825	—
Czechoslovakia ...	2,500	4,600	—
Ceylon	109	109	—
Honduras	35	71	—
Taiwan	4,133	4,133	—
Dominica	—	399	—
Greece	—	—	999
Aden	—	—	100
Morocco	—	—	3,500
Others	100	100	—
Total	**499,794**	**1,189,054**	**1,142,253**

* includes 12,000 tons shipped to Sweden.

MEXICO

Production	*Pan American Sulphur Co.*	*Gulf Sulphur Corporation*	*PEMEX and Texas Gulf Sulphur*	*Negociacion Minera de Azufre SA*	*Total*
1958 November ...	72,981	23,316	15,000	1,400	112,697
December ...	74,794	24,033	14,975	1,520	115,322
1959 January	66,862	23,004	15,000	1,400	106,266
February ...	67,184	24,424	14,060	1,422	107,090
March	72,941	26,620	15,620	1,500	116,681
April	63,188	25,237	16,000	1,500	105,925
May	69,140	23,093	15,200	1,591	109,024
June	73,166	25,144	14,500	1,500	114,310
July	87,643	26,833	16,000	1,500	131,976
August	78,231	25,270	17,000	1,500	122,001
September ...	72,577	23,407	17,000	1,600	114,584
October	83,987	20,158	16,480	1,500	122,125
November ...	75,669	20,719	16,800	1,500	114,688
December ...	75,755	18,559	17,000	1,500	112,814

CYPRUS

IRON PYRITES EXPORTS

	Jan.–Oct. 1958	*Jan.–Oct. 1959*
United Kingdom	125,359	146,393
Belgium	37,287	35,383
France	157,143	143,893
W. Germany	207,525	131,260
Italy	61,725	37,968
Netherlands	124,593	110,297
New Zealand	—	3,000
Total	**713,632**	**608,194**

CUPREOUS PYRITES EXPORTS

	Jan.–Oct. 1958	*Jan.–Oct. 1959*
Belgium	8,380	18,060
W. Germany	37,076	42,080
Italy	53,309	44,682
Netherlands	93,865	162,387
Total	**192,630**	**267,209**

SPAIN

PYRITES EXPORTS

Metric Tons

	Jan.-Aug. *1958*	Jan.-Aug. *1959*
Germany	308,486	293,582
Austria	17,663	20,292
Belgium	73,259	80,405
Denmark	44,158	50,449
France	144,716	73,326
Poland	39,491	4,432
Algeria	8,400	1,152
Holland	12,695	11,892
Ireland	11,166	16,399
Switzerland	3,795	3,006
Italy	22,033	14,789
Egypt	32,362	9,705
U.K.	—	14,931
Hungary	—	4,722
Czechoslovakia	—	5,598
Others	3,002	—
Total	**721,226**	**604,573**

PORTUGAL

PYRITES EXPORTS

Metric Tons

	Jan.–Nov. 1958	*Jan.–Nov. 1959*
Morocco	1,500	1,500
Tunisia	6,150	7,225
United Kingdom	3,601	—
W. Germany	52,030	57,251
Belgium	94,143	120,003
France	40,710	59,937
Holland	92,938	78,424
Algeria	2,050	1,170
Ireland	—	3,608
U.S.A.	1,616*	1,768*
Mexico	149*	—
Total	**294,887**	**330,886**

* Auriferous pyrites

O.E.E.C. †

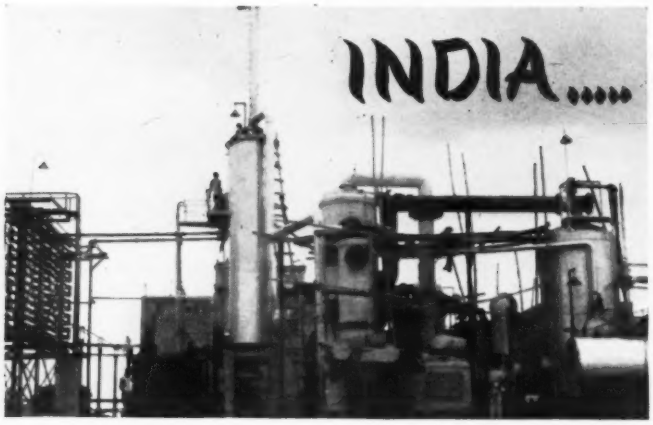
PRODUCTION OF SULPHUR IN ALL FORMS IN 1958

Thousand metric tons of sulphur content

Country	Native Sulphur	Recovered Sulphur	Pyrites	Zinc Blendes	Anhydrite	Spent Oxide	Mining Waste	Total
Austria	—	0.4	0.4	3.6	88.1	1.8	—	94.3
Belgium	—	0.4	—	—	—	2.6	—	3.0
Denmark	—	—	—	—	—	n.a.	—	n.a.
France	—	132.4	144.0	6.7	—	6.5	—	289.6
Germany	—	73.7	226.3	n.a.	—	n.a.	—	(300.0)
Greece **	3.5	—	129.6	8.6	—	0.1	—	141.8
Ireland	—	—	—	0.9	—	—	—	0.9
Italy	163.2	4.0	680.0	58.0	—	6.0	67.0	978.2
Netherlands	—	21.2	—	—	—	4.5	—	25.7
Norway	—	90.6	191.6	5.9	—	—	—	288.1
Portugal	—	17.7	275.2	—	—	—	—	292.9
Sweden	—	34.0	164.2	37.2	—	—	—	235.4
Switzerland	—	—	—	—	—	1.3	—	1.3
Turkey	12.8	—	32.6	—	—	—	—	45.4
United Kingdom	—	50.4	0.5	—	159.2*	119.2	—	329.3
Total	**179.5**	**424.8**	**1,844.4**	**120.9**	**247.3**	**142.0**	**67.0**	**3,025.9**

* Relates to sulphuric acid only. ** Figures for 1957. n.a. Not available

† Based on data presented by the Chemical Products Committee of O.E.E.C.



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List of products	Manufacturers of each individual product of all German chemical concerns located in West Germany and in West Berlin, together with the respective commercial firms, are listed under more than 10,000 headings.
Registered trade names	The most comprehensive list so far published of about 4,000 registered trade names together with details of products supplied by the manufacturing firms.

ENGLISH, FRENCH and SPANISH TRANSLATIONS of products and indexes greatly facilitate use by foreign firms.

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